A METHOD FOR ECONOMICALLY EVALUATING AND REFINING FUTURE PULPWOOD HARVESTING MACHINES IN CONJUNCTION WITH FOREST PLANNING AND MANAGEMENT

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A METHOD FOR ECONOMICALLY EVALUATING
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SUMMARY

Pulpwood harvesting operations are being mechanized in response to labor shortages and paper demands. Current fully mechanized harvesting equipment is limited due to design problems and current forest planning and management policies.

Forest planning and management policies and harvesting machine design should be developed and refined in conjunction with each other and management objectives.

A future harvesting machine design is proposed to eliminate or reduce many of the design problems in current harvesting machines. The purpose of this work is to evaluate forest planning and management alternatives in conjunction with the proposed harvester design and management objectives of the independent landowner (assumed maximum rate of return on expenditures) and the paper company (assumed minimum wood growing cost). The results of the evaluation are used to determine forest planning and management alternatives that optimize the management objectives and the related tree and forest characteristics for which to specialize and refine the proposed harvester design.

A harvester simulation model is developed, in GPSS II computer language, to determine the tree processing time of the proposed harvester relative to tree and forest characteristics. A forest growth model is developed, in DYNAMO computer language, to determine tree and forest characteristics relative to forest planning and management alternatives. An economic model is developed, in DYNAMO computer language, to evaluate

the proposed harvester design and forest planning and management alternatives in conjunction with each other and management objectives.

It is concluded that future harvesting machine design and forest planning and management policies should be developed in conjunction with each other and management objectives. Computer simulation is a valuable tool in accomplishing this objective. The proposed harvester design, in conjunction with optimal forest planning and management alternatives, significantly increases current production rates and reduces current harvesting cost. Tree characteristics for the harvester specialization and refinement as well as the optimal forest planning and management alternatives are identified as a result of this work.

CHAPTER I

INTRODUCTION

Purpose

Forest planning and management policies and harvesting machine designs should be developed in conjunction with each other so as to optimize economic objectives. The purpose of this work is to economically evaluate forest planning and management alternatives in conjunction with a proposed future harvesting machine design. The proposed harvesting machine is designed to eliminate or reduce many design problems in current harvesting machines. The evaluation is based on management objectives of the independent landowner and the paper company. The results of this evaluation are used to determine forest planning and management alternatives that optimize the management objectives and identify the related tree and forest characteristics for which the proposed harvester design should be specialized and refined.

Nature of the Problem

Normally, the independent landowner desires the maximum rate of return on forest investment and growing cost; whereas the paper company desires minimum wood growing cost. The economic evaluation of forest planning and management alternatives, in conjunction with the proposed harvester design, is based on these management objectives of the independent landowner and the paper company.

Harvesting machine designs are affected by forest planning and management alternatives and optimal forest planning and management alternatives are dependent upon harvesting machine designs. In view of this, it is desirable that the proposed harvesting machine and forest planning and management alternatives be evaluated and refined by an iterative process.

In order to conduct the evaluation, it is necessary to determine the harvester production rate and related harvesting cost relative to tree and forest characteristics. The traditional method for determining harvesting equipment production rates and related costs is to build a prototype model and evaluate the design by experimenting with the model.

In view of the costs and limitations related to prototype model construction and experimentation, computer simulation is a more economical and versatile method to determine the proposed harvester's production rate relative to tree and forest characteristics. A harvester simulation model is developed to determine the harvester's production rate by simulating the time required for each movement in harvesting a sample forest with specific tree and forest characteristics. The time required for each movement is based on the proven performance of currently available components utilized in the harvester design. The proposed harvester's performance, relative to tree and forest characteristics, is readily determined by simulating the harvesting of a variety of forests with specified tree and forest characteristics.

The proposed harvester's hourly operating cost is determined from the initial cost and related operating cost of components utilized in the harvester design.

It is necessary to relate the proposed harvester operating cost to forest planning and management alternatives. The harvester's production rate and related harvesting cost is a function of tree and forest characteristics. Therefore, a tree growth computer model is developed to determine tree and forest characteristics relative to forest planning and management alternatives. The tree growth model is based on established tree growth characteristics.

The forest is a long-term investment and there are many factors that affect the independent landowner's rate of return and the paper company's wood growing cost. It is desirable that forest planning and management policies, established at planting time, be compatible with harvesting operations and policies that will exist many years in the future. These policies must consider economic factors over many years of forest growth. The initial land investment, site clearing cost, site preparation cost, and site planning cost at planting time are some of the costs initially incurred. Tax and management cost, as affected by inflation, are ongoing costs. The value of the forest at harvesting time is affected by inflation, forest yield, stumpage prices, and harvesting cost. The harvesting cost is a function of machine design, inflation, and characteristics of the trees and forest.

An economic model is developed to economically evaluate forest planning and management alternatives in conjunction with the proposed machine design and management objectives. The economic model utilizes the results of the forest growth model and the harvester simulation model.

Statement of the Objective

The objectives of this work are as follows:

(1) Determine the forest planning and management alternatives (planting density and harvesting age relative to site index and site clearance requirement) that provide the independent landowner with a maximum rate of return (adjusted for harvesting cost) on forest investment and growing cost and the paper company with a minimum wood growing cost (adjusted for harvesting cost) when the forest is harvested with the proposed harvester.

(2) Determine the tree and forest characteristics resulting when optimal forest planning and management alternatives are utilized in order to identify the characteristics for which the proposed harvester design should be specialized and refined.

(3) Determine the independent landowner's maximum rate of return (adjusted for harvesting cost) on the forest investment and growing cost as well as the paper company's minimum growing cost (adjusted for harvesting cost) when optimal forest planning and management alternatives are utilized.

(4) Determine the harvesting cost per cord when optimal forest planning and management alternatives are utilized.

(5) Determine the proposed harvester's productivity when optimal forest planning and management alternatives are utilized.

(6) Determine the harvesting cost percentage of the combined wood growing cost and harvesting cost and the percentage of the combined stumpage price and harvesting cost when optimal forest planning and management alternatives are utilized.

(7) Determine the sensitivity of the landowner's rate of return on forest investment and growing cost, the paper company's wood growing cost, and the harvesting cost relative to variance from the optimal forest planning and management alternatives.

(8) Determine the reduction in maximum wood volume yield caused by optimizing the rate of return and wood growing cost.

Scope and Limitations

The proposed harvester design utilizes existing machine components which were commercially available at the time of this work and which have established performance characteristics. The harvester's initial cost and operating cost is based on the initial cost and related operating cost of these components at the current time of this work. The harvester simulation model is based on the established performance characteristics of these components.

The proposed harvester is designed to process trees with a maximum D.B.H. (diamater at breast height) of 12 inches and a maximum tree weight of 1,500 pounds. The harvester is also designed to process a maximum stem length of 50 feet in a single processing sequence. Trees 65 feet high are assumed to have a 50 foot merchantable stem. The harvester is not recycled for the small volume of wood in the tops of trees over 65 feet high. The volume lost in the top above 50 feet, in trees over 65 feet high, is accounted for by the economic model.

The harvesting operation is limited to the processing of trees into unit loads. The unit loads are deposited on the ground in the immediate vicinity where they are processed.

The harvester simulation model simulates the harvesting of forests with initial planting densities of 200 to 1,000 trees per acre (in 100 trees per acre increments) at survival percentages of 65, 70, 75, and 80 percent with trees of 5, 6, 7, 8, 9, and 10 inch D.B.H.

Forest planning and management alternatives in conjunction with the harvester design are evaluated relative to economic management objectives of the independent landowner and the paper company. The independent landowner's management objective is assumed to be maximum rate of return on the forest investment and growing cost. The independent landowner's rate of return is determined both where site clearance is required and where site clearance is not required. The paper company's management objective is assumed to be minimum wood growing cost when the paper company grows its own wood. The paper company's wood growing cost is determined when the paper company utilizes industrial funds for the forest investment and growing cost both where site clearance is required and where site clearance is not required. The industrial funds are assumed to normally produce a 15 percent return on investment and be taxed at a 40 percent corporate income tax rate. In view of this, the resulting opportunity cost of the funds is 9 percent (annually). Also, the paper company's wood growing cost is determined when the paper company borrows funds (at 6 percent annual interest) for the forest investment and growing cost where site clearance is required.

A standard harvesting cost allowance is used to make the stumpage price and wood growing cost responsive to harvesting cost. When the harvesting cost exceeds the harvesting cost allowance, the stumpage price is decreased and the wood growing cost is increased accordingly. When the cost is less than the harvesting cost allowance, the stumpage price is increased and the wood growing cost is decreased accordingly. The standard harvesting cost allowance is set at 1.50 dollars at planting time and increased at the inflation rate in subsequent years.

All forest planning and management alternatives considered are for slash pine plantations. Only clear-cutting operations are considered. The forest planning and management alternatives considered are harvesting age (0 to 40 years) at various initial planting densities (200 to 1,000 trees per acre in 100 trees per acre increments) for the following site indices: 40, 50, 60, 70, and 80.

All costs in this work are based on the inflation rate and costs available in 1968. Planting time is considered to be in 1968.

Due to the long-term nature of the forest, inflation has a significant effect on forest economics. The inflation rate is assumed to be at a compound annual rate of 3 percent. At this rate, values (affected by inflation) change more than 100 percent in 25 years.

The tree and forest characteristics identified as the characteristics for which the harvester should be refined are the characteristics resulting when the optimal forest planning and management alternatives are utilized.

The effects on ecology and non-forest land uses are not considered in this work.

Procedure

The procedure used to evaluate forest planning and management alternatives in conjunction with the proposed harvester design and management objectives is as follows:

(1) Develop a harvester simulation model, in GPSS II computer language, to simulate the proposed harvester when harvesting forests with specified tree and forest characteristics.

(2) Experiment with the harvester simulation model and a sample forest with specific tree and forest characteristics to determine the harvester's processing time per harvestable tree relative to initial planting density, tree survival, and tree D.B.H.

(3) Develop a forest growth model, in DYNAMO computer language, to determine the tree and forest characteristics relative to forest planning and management alternatives.

(4) Experiment with the forest growth model to determine the tree and forest characteristics (tree height, tree D.B.H., tree weight, tree volume, tree survival, tree basal area per acre, and wood yield per acre) relative to forest planning and management alternatives (site index, initial planting density, and harvesting age).

(5) Develop an economic model, in DYNAMO computer language, to determine (relative to forest planning and management alternatives) the independent landowner's rate of return on the forest investment and growing cost as well as the paper company's wood growing cost when forests are harvested with the proposed harvester.

(6) Experiment with the economic model to determine the independent landowner's rate of return, the paper company's wood growing cost, the harvesting cost, and data related to forest planning and management alternatives (site index, initial planting density, and harvesting age).

(7) Analyze the results of the experimentation with the 3 models to satisfy the objective of the research.

CHAPTER II

BACKGROUND OF THE PROBLEM

The paper industry in the Southeastern United States is now facing a potential wood supply crisis due to problems in producing and harvesting pulpwood (1). In the past, the paper industry directed major efforts toward improving paper manufacturing while practically neglecting production and harvesting of wood. This was made possible, and even profitable, by large wood reserves and abundant available labor which no longer exists. In recent years, the paper industry and equipment manufacturers have made efforts to improve harvesting operations by limited mechanization. Improvements in productivity per work unit have resulted but are inadequate to resolve the problems. It is now necessary that efficient high performance harvesting systems be developed in conjunction with future forest management practices so that adequate solutions will be available to combat the pending crisis.

Forest Growth Problems

In 1968, Dyck (1) reported that the United States had some 509 million acres of commercial forest land and, during 1966, these lands produced approximately 55 million cords of pulpwood. The U. S. Forest Service estimates the demand to be 101 million cords in 1985. This is an 84 percent increase in demand for pulpwood in 20 years.

Between 1953 and 1963, commercial forest acreage increased 1.5 percent. However, a million or so acres of forest land is being taken annually for agriculture, right-of-ways, residential developments, industrial sites, and the like. This unpredictable give-and-take tends to transfer the more productive and accessible forest land into other uses while worn-out and less desirable land reverts to forest use. The need for land-use planning, on both a local and a national scale, becomes ever more apparent from the standpoint of all potential uses. It is especially pressing for forestry because the growing of trees and other major wild land uses are long-term operations requiring assurance that the land will be available long enough to produce the desired return (2).

Improvement of the forest land availability in the long-term (1985 to 1995 and beyond) is very pessimistic. Conversion of forest lands into agricultural lands is a logical outcome of the rapidly developing world-wide food problem. The only hope seems to lie in intensive forest management programs that promise productivity increases of over 30 percent (1).

The forests that must produce increased yields when they are harvested during 1990-2000 time period must be properly planned today and scientifically managed. The current land ownership patterns and related economics are not very responsive to this fact and can lead to serious consequences. This problem is especially critical in the South where the bulk of the pulpwood is obtained from small woodlands held by independent owners. Business Week (3) reported in 1968, that though their numbers are diminishing, small timber holdings (10 to 20 acres) predominate the pulpwood business by comprising 52 percent of all available timberland.

The small landowners are made up of a variety of individuals. A large majority are farmers, many being small farmers, whose major interest in the land is related to agriculture. Other groups who tie up an ever-increasing woodland acreage are business executives and professional people who acquire these lands for recreational and retirement purposes. Due to their scale of operation, these small landowners do not scientifically plan and manage their forest. Currently, there is not an economic incentive for these small landowners to increase their land yield.

It is not desirable for the paper companies to attempt to buy sufficient land to satisfy the wood demand. Land ownership is very important to a very large segment of the American public. In view of this, it is very doubtful if the public would allow a few large companies to control such a large percentage of land.

The only practical solution seems to be mutual cooperation between the paper companies and the small landowners. With an adequate incentive, the small landowner is probably interested in forest planning and management to increase yield. Expensive high production equipment is required to properly prepare, plant, and harvest the forest efficiently. If the paper companies develop a pool of such equipment, they can prepare, plant, and harvest the small landowner's land at reasonable costs and insure the landowner adequate return on investment. This is desirable to the landowner because it helps insure an adequate return on investment, and it is desirable to the paper company because it helps insure an adequate wood supply. The small acreage problem can be alleviated by systematically scheduling operations on small land acreages in the immediate vicinity of each other.

Forest Harvesting Problems

In addition to problems related to land planning and management, there are severe labor problems developing that must be resolved to provide adequate harvesting capacity in accordance with future pulpwood demands (4). For many years, the national economy provided an abundant and cheap labor supply. In this labor environment, pulpwood harvesting requirements were readily accomplished by manual operations. During this time, working conditions were characterized by low wages, irregular work, excessive physical exertion, and excessive exposure to adverse forest environments. The national economy began to improve while the paper industry was making little effort to improve harvesting operations and related working conditions. The expanding economy produced a large demand, in urban centers, for labor to fill jobs that offered good wages, regular work, and improved working conditions. The paper industry was then confronted with an expanding demand for paper in a dwindling labor force that was demanding better wages and improved working conditions.

Development of the lightweight power saw, during the early 1950's, was the first major effort to eliminate some pulpwood harvesting dependence on manual power. The power saw was followed by the powered cable hoist mounted on the haul truck to relieve the burden of loading the pulpwood.

In 1950, the logging industry required approximately 200,000 men to produce almost 21 million cords of pulpwood. In 1961, 220,000 men produced 40 million cords. Production during this 11 year period almost doubled with only a 10 percent increase in manpower requirements. The introduction of the chain saw, improved truck handling equipment, mechanized reloading yards, and chip residue programs had a dramatic effect on the drop in manpower needs (4).

When the power saws and truck mounted cable hoists were developed, they were naturally adapted to the existing small pulpwood harvesting crews. Due to their related small investments, low skill requirements, and increased labor productivity, they were readily incorporated into existing operations.

By the early 1960's, further advances in mechanization were made by the introduction of the articulated skidder (4 wheel drive and rubber tires) and hydraulically operated pulpwood handling equipment. These advances increased productivity and reduced manual effort, but they were not readily incorporated into the existing harvesting operations which were performed mostly by small crews. This equipment required much higher initial investments, increased operator training, increased maintenance, higher operating costs, and more management planning. It was difficult to upgrade the small harvesting crews with this equipment due to their limited financial resources, scale of operation, and training. Only the larger harvesting crews and the paper company's harvesting crews were adaptable to this equipment.

The paper companies and equipment manufacturers continued in the development of harvesting equipment that would fully mechanize pulpwood harvesting. According to Rolston (3), the ideal of mechanization was to be reached when a worker did not have to get on the ground. Equipment was placed on the market by the mid and late 1960's that satisfied this goal of full mechanization.

The Buschcombine, the first fully mechanized harvesting system, was first placed in service in 1964. While operated by one man, it fells, delimbs, measures, bucks, pre-hauls, and loads 1.1 cord bundles of 5 foot, 6 inch bolts onto a pallet or truck. It was the first machine to utilize hydraulic shear cutting of wood, which has been utilized in many other subsequent designs. It is designed to process a tree with a maximum diameter of 19 inches (5). Its manufacturer terms the Buschcombine as a mass production line concept that has more than tripled the labor output.

The Koehring Processor, introduced 3 years after the Buschcombine, has a similar production sequence. This machine has a tree-processing boom that performs a continuous downward operation while topping, limbing, and bucking. The resulting 8 foot bolts are conveyed to, and accumulated in, a rear grapple that loads them on haul trucks when a load is formed. This machine is designed for a maximum diameter of 16 inches (5).

Sicard and Logging Research Associates have developed similar fully mechanized systems that utilize a feller-buncher and a wood processor. The feller-buncher hydraulically shears the trees from the stump and deposits them in a storage grapple. When a load is formed, the feller-buncher transports the trees to the processor for additional processing. The processor tops, delimbs, measures, bucks and deposits the pulpwood bolts in bundles. The bundles of bolts are then loaded on trucks for hauling. The Logging Research Associates' processor also debarks the trees. The Sicard and Logging Research Associates' systems are designed for a maximum tree diameter of 16 and 18 inches, respectively.

Omark and Beloit harvesters are similar fully mechanized systems that have a hydraulic shear, delimber, and bucker mounted on a hydraulically operated boom. These machines sever the tree from the stump with a hydraulic shear while securing the stem with the boom. The boom then tops, delimbs, measures, bolts, and stacks the wood on the ground. The Omark system is designed for a maximum tree diameter of 17 inches. The Beloit system is designed for a similar maximum tree diameter.

All of these fully mechanized harvesting systems have greatly increased man-machine productivity over the less mechanized systems. In most cases there has been some reduction in harvesting cost. The greatest problem related to these fully mechanized systems is their cost. All of them cost more than 50,000 dollars each. In general, the paper company's harvesting crews are the only crews that can utilize this equipment due to its initial cost.

These machines are the first generation of fully mechanized harvesting systems and they lack refinement. The machines have a poor cost-productivity ratio. The major limitation on their production rate is caused by designs that allow only one operation to be performed on only one tree at a time while much of the machine and the operator are idle or improperly utilized. These machines are also designed for too wide a range of tree sizes. All of them are designed to harvest trees with at least 16 inch diameters. Preliminary analysis of the economics related to tree growth indicates that it is not economical to even grow trees to a 12 inch diameter. This is further verified by this work. A review of tree characteristics indicates a tree with a 16 inch diameter weighs approximately twice as much as one with a 12 inch diameter and approximately 4 times as much as one with a 9 inch diameter. The machine design, cycle time, and operating cost are closely related to the maximum size tree a machine is designed to harvest.

In view of the above, future harvesting machine designs and future forest planning and management should be developed in conjunction with each other and the related management objectives.

Evaluation of Forest Growth and Harvesting Problems

In the past, there has been considerable difficulty in evaluating forest planning and management alternatives and harvesting equipment design. Harvesting equipment design was normally evaluated by experimentation with equipment after it was fabricated. Evaluation of forest planning and management alternatives was limited by the long-term nature of the forest. The development of the electronic computer in the 1950's and the increased refinement and availability since that time has recently made possible the evaluation of forest planning and management alternatives, as well as harvesting equipment design, by computer simulation.

In the past 15 years, the cost of arithmetical computations has decreased by a factor of 10,000 or more in those areas where digital computers can be used in their most efficient modes of operation. The appearance of the electronic computer has removed the practical computational barrier. Since the early 1950's, the computer's speed, memory capacity, and reliability have increased approximately tenfold per year. Overall, this is a technological change greater than that effected in going from chemical to atomic explosions. Society cannot absorb such a change in this length of time. We have a tremendous untapped backlog of potential applications of this advancement. Since computing machines are now so widely available and the cost of computation and machine programming is so low relative to other costs, former difficulties in activating simulation models need no longer determine our rate of progress in understanding system dynamics (6).

Computers are essential for massive calculations connected with stand and harvester simulation models. Other potential uses will undoubtedly affect the entire spectrum of forest management in the future (7).

Simulation is the technique of evaluating a system's performance through experimentation performed on a mathematical model representing the real world system. According to Mao (8), the simulation study should start with the construction of a mathematical model designed to capture the essence of the relevant features of the real world, thereby revealing the functional relationships among the variables being investigated. The mathematical model serves as a medium of statistical experimentation. This usage of a mathematical model in simulation is what distinguishes simulation from optimization where mathematical models are solved analytically rather than experimentally. It would be ideal if we could readily derive analytical solutions from all of our mathematical models. Unfortunately, this is sometimes impossible since a problem may be so complex that either it has no analytical solution or it has an analytical solution which is too costly to derive.

Since mathematical models in simulation studies serve as the basis of experimentation, the focus in their construction is on specifying the interrelationships between the individual elements making up the problem and on describing the randomness in these elements. These mathematical models, when activated with actual data, enable the analyst to forecast the kind of results that can be expected under actual conditions. By repeating the experiment many times for each alternative policy and by comparing outcomes, a policy can be chosen which produces the best simulation results (8).

Simulation of pulpwood harvesting machinery has recently attracted much attention because the forest industry is striving to reduce the cost of wood fiber at the mill. The place where the greatest cost reduction can be achieved is in cutting the tree and getting it to the roadside in a form which can be readily transported to the mill (9).

Simulation testing has many advantages over field testing of harvesting equipment. The method is much faster than field testing. A test, in which a 1,000 tree forest is harvested, can be made on a computer in less than a minute. The effect of varying the machine size can be tested without the expense of modifying the machine. The machine can be tested in a wide range of stand conditions using data from either actual or hypothetical stands. All tests can be made on the same stand, thus eliminating the "between stand" variations. This is not possible with field testing because a stand can only be harvested once; in the computer it can be reharvested as many times as necessary. Using the simulation technique, it is possible to study the effect of varying one machine or stand characteristics while keeping the remaining characteristics constant. In practice, this is seldom possible as varying one characteristic usually alters others. The disadvantage of simulation models with new designs is the availability of related data for comparison so that model accuracy can be determined (10).

A forest stand model is very valuable in providing guidance in planning and managing future forests. A stand model is a simulation model that can be used to describe forest growth on an individual tree basis. This makes it a useful tool in forest management research for studying the effect that different initial spacing and different thinning treatments have on subsequent stand development. Results can be obtained in only a few minutes of computer time; whereas in real life, perhaps 100 years would be required. The researcher can afford to take risks and experiment with unusual treatment because failure, at the worst, means wasting a few dollars worth of computer time (7).

The growth rate of a tree in a given stand and site depends on its diameter, age, and the amount of competition. Diameter and age data are relatively easy to obtain but competition is an imponderable factor. Competition is known to be at a minimum when the tree is open-grown and at a maximum when the tree is suppressed and about to die. There is probably a "zone of influence" or "occupancy" around each tree and the area of this zone can be safely assumed to be proportional to the size of the tree. The situation can be stated more simply by using the D.B.H. to measure "size" and by assuming that the "zone" is a circle. The radius of the circle is assumed directly proportional to the D.B.H. Unfortunately, the value or "competition radius factor" by which the D.B.H. must be multiplied is unknown (7).

Computer simulation models can provide valuable guidance to the independent landowner and the paper company in determining forest planning and management alternatives that optimize economic (business) objectives.

In view of the intricately complex nature of business systems, it is difficult to evaluate new management concepts or system designs. Direct experimentation poses almost insurmountable problems due to disruptions, uncontrolled results, length of time required, and the possibility of costly mistakes. Computer simulation, on the other hand, has been shown to provide a suitable methodology to study business system behavior under a variety of conditions and provide a means for analysis of simultaneous interaction of the many system variables to yield valuable insights (11).

Initially, computer programming problems were the major stumbling blocks in developing simulation models. This was caused by the requirement to program the model in machine language which required a detailed understanding of computer operations. This difficulty has been greatly reduced by the development of specialized compiler language. Specialized compiler languages are designed for specific modeling techniques. The compiler language converts the model equation into machine language, thus eliminating the need for one to understand the many details of machine language.

The compiler languages used in this work are DYNAMO (12) and GPSS II (13).

The DYNAMO compiler language is readily adapted to dynamic feedback systems in business, economics, and engineering due to its ability to translate mathematical models into tabulated and plotted results (12). The DYNAMO program computes instant program variables at time intervals which are identified by the program symbol DT. The time instant at which computations are made is called the K computational instant. The prior computational instant is identified as the J instant and the instant of the next computation is identified as the L instant. The time interval between these computational instants is identified as the JK and KL intervals (12).

There are 3 principal types of variables in DYNAMO: levels, rates, and auxiliaries. A level is a quantity calculated at the K computational instant and its value depends upon its value at the J computational instant, other variables at the J instants, and values of rates at the JK interval. Rates are variables that represent the changes between computational instants. Rates are computed at the K instant for the KL interval from levels and auxiliaries at the K instant, and occasionally from rates at the JK interval. Auxiliaries are variables that are introduced to simplify the algebraic complexity of rate equations. Auxiliaries are computed at the K instant from levels and other auxiliaries at the K instant, and occasionally from rates at the JK interval. DYNAMO consists of approximately 10,000 instructions written in machine language. DYNAMO can handle simulation models with up to 1,400 equations (12).

GPSS II (General Purpose Systems Simulation II) compiler language is readily adaptable to process flow simulation. This language allows the user to study the logical structure and the flow of traffic through the system. It is possible to simulate the interdependence of variables in the system such as queue lengths, input rates, and processing time. Material flows are simulated by transactions and each transaction is assigned definitive values. Operations on the material flow are simulated by facilities. The operating time for each facility is based on constants, functions, or variables as programmed in the model. The transaction flow logic can be programmed to simulate the actual flow logic. The simulated time, at any point in the flow of a transaction, may be recorded as can also a variety of statistical data related to the simulated flow of material through the simulated system. GPSS II can simulate 1,000 transactions processing through 200 facilities (13).

In this work, DYNAMO compiler language is used in a combined forest growth and economic simulation model; whereas GPSS II compiler language is used in a harvesting machine simulation model. The objective of this work would be unfeasible without the use of such simulation models.

CHAPTER III

HARVESTER DESIGN CRITERIA

Fully mechanized harvesting systems have been developed in response to decreasing labor resources and increasing wood demands as well as increasing productivity requirements. The current fully mechanized systems are first generation designs and lack refinement. Their productivity is limited mainly due to inadequate specialization of design, insufficient automation, improper sequencing of operations, and excessive handling of individual trees and bolts. In general, the designers of these systems concentrated too much on getting the operator off the ground and not enough on efficient machine design and utilization.

Millar (14) reports that most of the important softwood and hardwood species in the United States are intolerant of shade which means they reproduce and grow best in stands of approximately the same age. He also states that "if they grow best this way, they should be managed this way." In view of this, it is interpreted that even age geometric planting, as is done in plantations, is a desirable forest planning and management policy. Such planning and management policies are also conducive to mechanized harvesting because of the resulting uniform tree size and spacing. A preliminary economic analysis is conducted to determine optimal forest planning and management policies relative to planting densities and harvesting ages for forest plantations. This analysis indicated that optimal policies would result in harvested tree D.B.H.s being less than 12 inches and a height less than 65 feet. This is verified in Chapters VIII and X of this work. As pointed out in Chapter II, all of the current fully mechanized systems are designed for maximum tree diameters of at least 16 inches. If these machines were designed for optimally planned and managed forests, their current use would be restricted due to the limited availability of such forests. But utilization of optimal policies should increase and the harvesting machine design should be specialized in accordance with these policies. As noted in Chapter II, a tree with a 16 inch diameter weighs approximately twice as much as one with a 12 inch diameter and 4 times as much as one with a 9 inch diameter. Machine design is closely related to the maximum tree size it must harvest. Normally, designs associated with larger trees require larger, slower, and more expensive components than designs associated with smaller trees. As a result, the machine designs related to the larger trees are slower and more expensive to operate. In view of this, current mechanized systems are designed for tree characteristics approximately twice those resulting from optimally planned and managed forests.

Current harvesting machines are normally designed so that the operator is required to control most of the processes as one tree is processed by the machine. It would be more efficient utilization of the operator to only require the operator to assist the machine at the beginning of the processing sequence with all subsequent operations being automated.

The sequencing of operations of current harvesting machines results in low machine and operator utilization. With current designs, only one operation is performed at any given time with only one tree at a time being processed by the harvester. With this design, the machine accomplishes several operations but many components are idle while only the components related to the operation being performed at that specific time are being utilized. Increased machine productivity can be realized if the harvesters are designed to simultaneously perform progressive operations on multiple trees as individual trees are progressively processed through each of the operations. As stated above, the operator should be utilized only to start each tree in this sequence of operations.

Some of the current fully mechanized systems have multiple machines harvesting trees in separate operations. This requires each tree to be partially processed by each machine. Each tree, or partially processed tree, requires individual handling to start the processing sequence with each machine. The excess handling increases harvesting cost. Other systems attempt to accomplish too much with a single machine by processing the tree into bolts and hauling them out of the forest. When a machine is designed and used for a tree processing function and a transportation function, only a limited percentage of the machine's capability can be used at a given time. It is impossible for trees to be processed at the stump and hauled in the very same operation at the same time. Therefore, it is desirable for one machine to be designed to completely process the tree into pulpwood and accumulate the pulpwood into units that can be readily transported. Specialized hauling equipment can then be utilized to transport these units out of the forest. In view of this, the harvesting operation in this work consists of processing trees into units of wood that are readily transported out of the forest and to the paper mill.

Considering the above design problems in current harvesting machines, a harvester design is proposed in this work to reduce or eliminate the noted problems. The design utilizes existing components which are commercially available and have established performance characteristics based on past usage data. In view of the results of a preliminary study, the design is for a maximum tree butt diameter of 12 inches, a maximum weight of 1,500 pounds, and an optimal height of 65 feet (50 foot harvestable stem). The operator is required to control the machine movement to the trees and the initial operation. While the operator is controlling the first operation, the harvester simultaneously performs automatic operations on multiple trees that are being progressively processed by the harvester.

The harvester processes the trees into 16 foot, 8 inch bolts which are stored in a grapple until a 13,000 pound unit is formed. When the 13,000 pound unit is formed, tree processing is interrupted while the load is deposited on the ground as a 13,000 pound unit for transportation. The trees are processed into 16 foot, 8 inch bolts because this length reduces processing and is readily loaded and transported. This size unit is efficiently transported in the forest and loaded on haul trucks. Four of these units form the maximum load (approximately) for efficient truck transportation (to the mill) on public roads.

CHAPTER IV

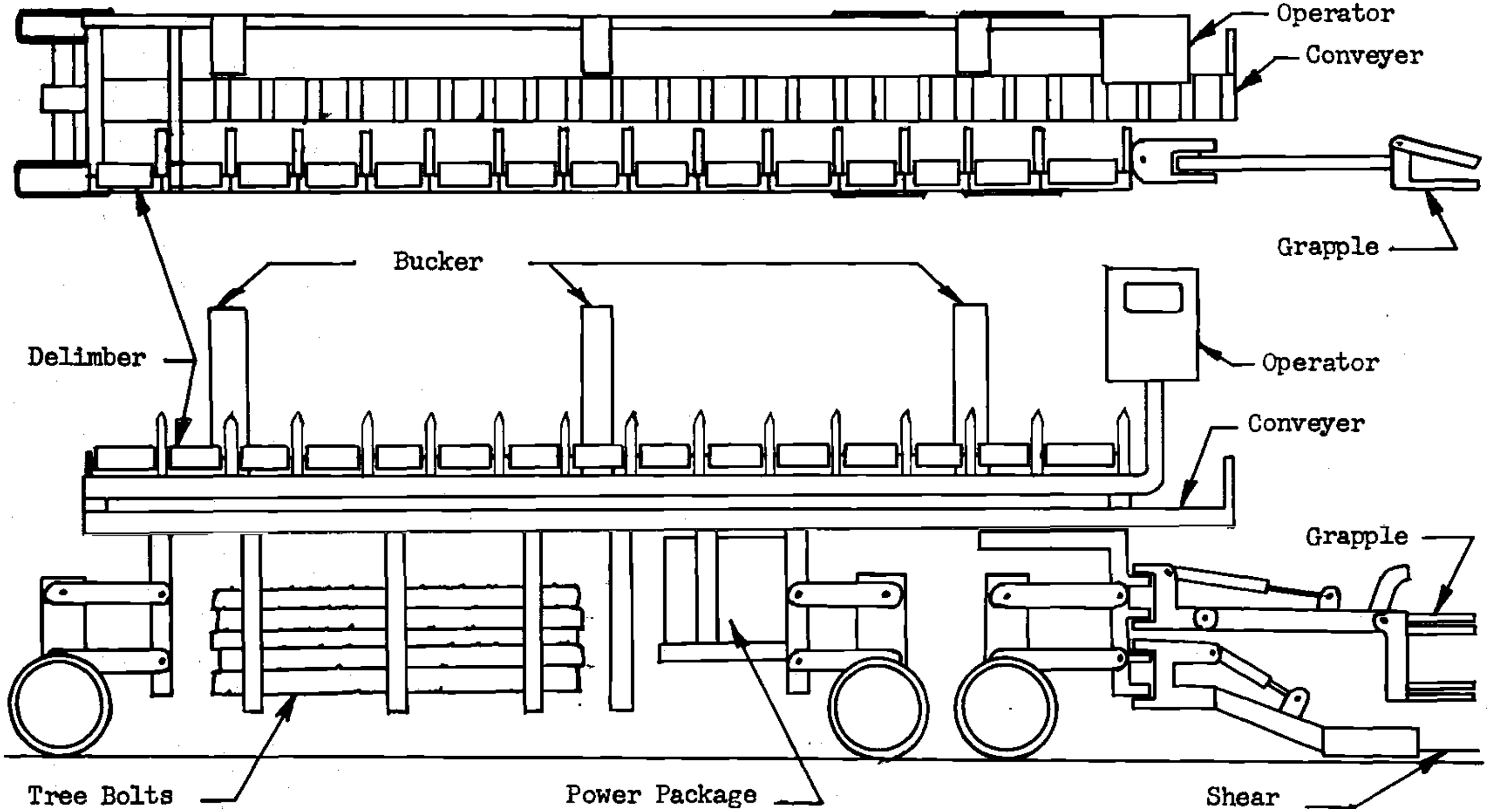
THE HARVESTER DESIGN

Discussion of the Harvester Operations

The pulpwood harvesting machine design, proposed in this work, requires limited operator control, incorporates automatic operations, provides an efficient sequence of operations, minimizes individual handling of trees, and utilizes existing machine components. A sketch of the proposed harvester is presented in Figure 1. A block diagram of the harvester operations is presented in Figure 2.

The harvester operation sequence begins with the operator identifying the tree to be harvested and then guiding the machine, specifically the shear, to the tree. When the operator has positioned the shear on the tree, he is ready to prepare for the next tree. All subsequent operations, excluding the unloading operation, are automatic. The shear severs the tree in two stages. The grapple is automatically positioned on the tree relative to the position of the shear. The first stage shearing partially severs the stem. The second stage shearing completely severs the stem, but it is not allowed to start until the grapple has secured the tree. When the tree is severed, the grapple raises the tree to a waiting position for delimber clearance. The shear is then available for the operator to guide it, and the machine, to the next tree.

When the delimber is clear, the grapple positions the tree in the delimber. The delimber then delimbs the tree and the grapple secures the



Estimated Weight: 50,000 Pounds

Scale: 1 to 90 1 Inch

Figure 1. Proposed Harvester Sketch

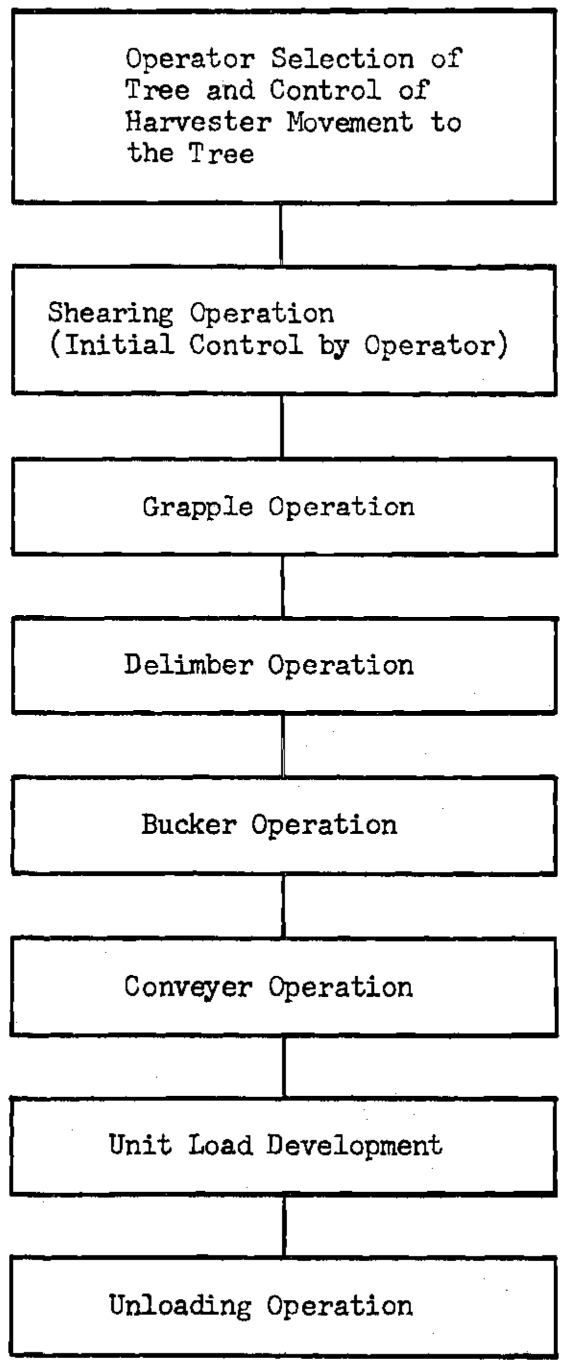


Figure 2. Block Diagram of Harvester Operations

next tree in the shear.

After delimbing and bucker clearance, the tree is flipped into the bucker. The delimber is then clear to delimb the next tree. The bucker shears the tree into three 16 foot, 8 inch bolts if the tree is long enough. If the tree is not 65 feet long, the top bolt will contain some of the top that is smaller than 3 inches.

When bucking is complete and the conveyer is clear, the bolts are flipped into the conveyer. The bucker is then cleared to accept the next tree from the delimber. The conveyer deposits the bolts in the storage grapple.

When the hydraulic suspension system senses that a 13,000 pound load is supported by the harvester, the operator is alerted. The operator stops processing additional trees into the machine and, as the last trees are processed through the harvester, he starts positioning the machine to deposit the unit load (approximately 13,000 pounds). When the load is deposited on the ground, the operator and harvester can then start processing the next unit load.

Discussion of Machine Components

Many of the components utilized in the harvester design are briefly discussed relative to major assemblies.

Shear

The shear is used to sever the tree from the stump by the shearing action of 2 blades. A hydraulic cylinder provides the cutting force. The shear is mounted on an arm that is equipped with a hydraulic cylinder to raise and lower the shear and a hydraulic cylinder to slue the shear horizontally.

Grapple

The grapple is used to position the tree in the delimber after the tree has been severed from the stump by the shear. The grapple is made up of a grapple assembly, a tree support, and a grapple arm. The grapple assembly has 2 clamps that secure the tree. Each clamp is operated by a hydraulic cylinder. The grapple assembly can be rotated beneath the grapple arm by a hydraulic cylinder. A movable tree support (operated by a hydraulic cylinder) is located on the top of the grapple arm to help support the tree as it is lowered into the delimber. The grapple assembly and the tree support are mounted on the end of the grapple arm. The grapple arm is equipped with 2 hydraulic cylinders, series mounted, to raise and lower the grapple arm and 1 cylinder to provide horizontal sluing of the arm.

Delimber

The delimber delimbs the tree by rotating the tree near a series of cutting heads. The cutting heads are operated by two hydraulic motors. The rotary motion of the tree is provided by a series of chain rotating mechanisms that are operated by hydraulic motors. The delimber is also equipped with a set of flips that hold the tree in the delimber during delimbing and discharges the tree into the bucker when the delimbing is complete. These flips are operated by hydraulic cylinders.

Bucker

The bucker is equipped with 3 shears that cut the tree into the desired lengths. A hydraulic cylinder provides the cutting force for each of the shears. The bucker also has 3 receiving flips to receive and hold the tree in the bucker and 6 discharging flips to discharge the tree bolts into the conveyer. Each of these flips is operated by a hydraulic cylinder.

Conveyer

The conveyer is comprised of a series of rollers to convey the bolts to the storage grapple. This series of rollers is divided into 3 sections. Each section is operated by a hydraulic motor. The rear section of rollers is located above the storage grapple. It can be tilted, by a hydraulic cylinder, so the bolts will fall into the storage grapple when the conveyer side gates are opened. The side gates are also operated by a hydraulic cylinder. The rear section of the conveyer is equipped with a shock absorbing stop (operated by a hydraulic cylinder) to stop the bolts.

Storage Grapple

The storage grapple stores the processed trees until a 13,000 pound load is formed. The storage grapple supports the load on 6 curved arms. Each of these arms is operated by a hydraulic cylinder. When a load is formed, the arms are opened to allow the load to be deposited on the ground.

Harvester Suspension System

The harvester is transported by 3 steerable axle assemblies. Each of the axle assemblies is powered by a hydraulic motor mounted on the differential. The harvester is supported on the axle assembly by 6 hydraulic cylinders. The steering of the axle assemblies is accomplished by hydraulic cylinders.

Power Package

The harvester's power source is 2 diesel engines (each rated at 220 continuous horse power). Each of these engines drives 3 hydraulic pumps.

The harvester design utilizes components that were available at the time of this research. The related cost and performance data for the components were obtained from the component distributors in the Atlanta area.

The total estimated cost of the proposed harvester, at the time of this research, was 99,000 dollars. The cost is summarized in Appendix I.

The total operating cost of the harvester, at the time of this research, was 30 dollars per hour. This cost is computed in accordance with guidelines published by The Caterpillar Tractor Company (15). The operating cost computations are presented in Appendix I.

CHAPTER V

DEVELOPMENT OF HARVESTER SIMULATION MODEL

Discussion of Harvester Simulation

In order to economically evaluate the design of the proposed harvester, it is necessary to determine its processing time per tree relative to tree and forest characteristics. Computer simulation is a flexible and economical method for determining the proposed harvester's tree processing time.

Development of a simulation model is much cheaper than construction of a prototype (the conventional method) and a model can produce reasonably accurate results. A simulation model is very flexible in that it is readily changed to simulate design modifications. A simulation model allows experimentation with many different simulated forests while the prototype requires actual growing and harvesting of the forests. The computer simulation also produces results faster because it simulates the harvesting operation in microseconds while the forest must be harvested with the prototype.

In view of the above, a computer simulation model is developed to simulate the harvester harvesting various forests with different tree and forest characteristics. Each of the operations is broken into the basic movements that are required to accomplish each operation. These movements are accomplished by hydraulic components such as hydraulic motors and cylinders. Since the machine design utilizes existing components which have established performance charcteristics, the estimated time to accomplish each movement is readily determined. The simulation model is programmed to simulate the time (in 0.1 second increments) required for each motion and the interdependence of various motions as they occur in the actual harvester.

The harvester simulation model is programmed in General Purpose Systems Simulator II (13) computer language. This language is used because of its adaptability to process flow simulation. The complete simulation model and sample printout are contained in Appendix II.

A detailed flow diagram of the harvester's processing sequence is presented in Figure 3. This flow diagram is used to explain the simulation model and the related harvester operations. Each processing movement, or series of movements, is represented by a circle and a number that is called a step. The sequence of steps is represented by solid lines and the interdependence of simultaneous steps is represented by dotted lines.

The following discussions of the harvester simulation subprograms relate each of the steps in Figure 3 to the model programming blocks of the computer program contained in Appendix II. Only the programming blocks necessary for a basic understanding of the computer simulation model are discussed.

Discussion of Harvester Simulation Model Subprograms

Forest Generator and Model Control Subprogram

Step 1. Tree transactions, representing trees to be harvested, are generated by the simulation program in blocks 1 and 2. Each transaction

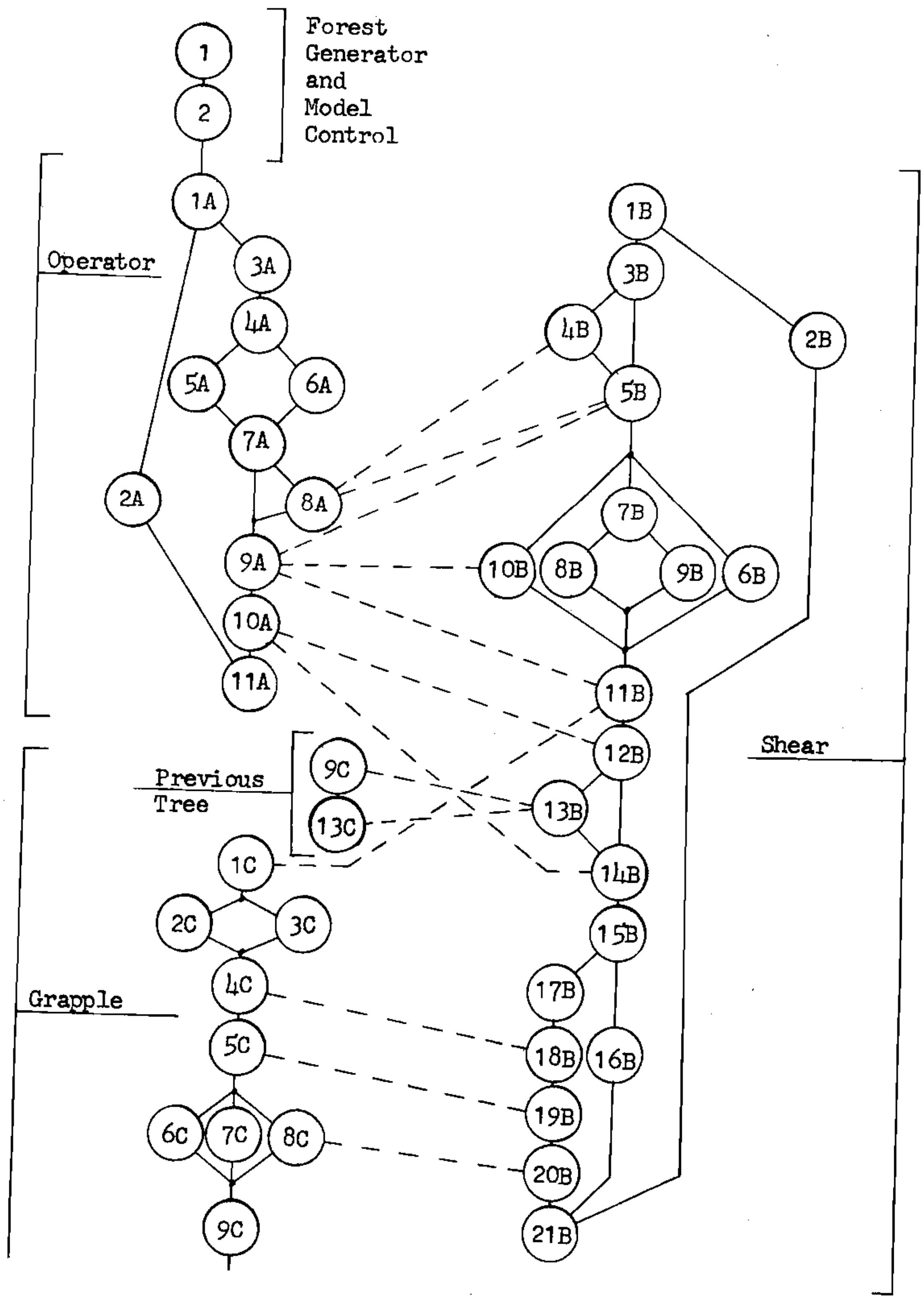


Figure 1. Detailed Flow Diagram of the Harvester Processing Sequence

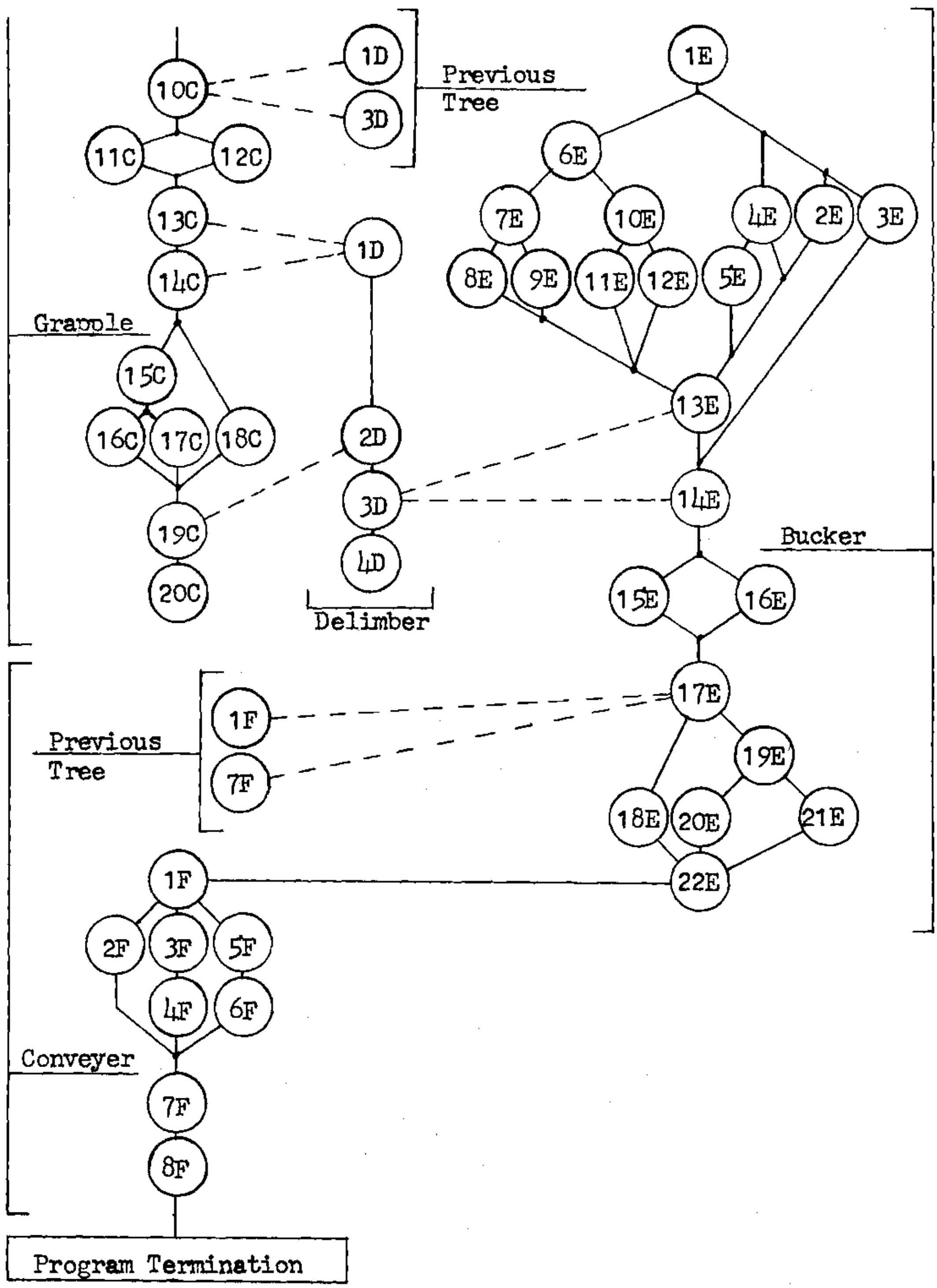


Figure 1. Detailed Flow Diagram of the Harvester Processing Sequence (continued)

has eight parameters to which specific tree and forest characteristics are assigned. Blocks 3, 4, 540, 5, 6, 7, 8, 9, 10, and 11 are used to assign tree and forest characteristics to parameters of each tree transaction as follows:

(1) Parameter 1 is assigned the tree D.B.H. in tenths of inches.

(2) Parameter 2 is assigned the tree height in feet.

(3) Parameter 3 is assigned the tree number.

(4) Parameter 4 is assigned the tree spacing in the row in tenths of feet.

(5) Parameter 5 is assigned the tree alignment in the row in tenths of feet.

(6) Parameter 6 is assigned the tree grade (a fatality is assigned a value of 3, a defective tree is assigned a value of 5, a harvestable tree is assigned a value of 10).

(7) Parameter 7 is assigned the tree terrain classification (5 classes depending on ground slope).

(8) Parameter 8 is assigned the types of cut (clear cut is assigned a value of 5 and a thinning cut is assigned a value of 10).

Step 2. Blocks 51 through 61 and 72 set savex values that are used as model controls during the simulation. Blocks 70, 74, 71, 75, 76, 77, 78, and 79 are used to create duplicate tree transactions that simulate the operations performed on the tree. Duplicate transactions are necessary because certain functions of different operations are conducted simultaneously in coordination with each other as the tree is processed through the harvester.

Operator Simulation Subprogram

Step 1A. This step provides model logic based on the value of parameter 6 (tree grade) of each tree transaction. Block 20 routes the transaction to step 2A if the tree is a fatality or to step 3A if the tree is a defective tree or a harvestable tree.

Step 2A. This step simulates the operator processing a fatality which actually does not require any time. Blocks 31, 32, 33, and 34 record the same clock time in savexes 101, 102, 103, and 104 so that 0 operating time is shown in the simulation printout. A fatality is identified in the printout by 0 operating time. The model is programmed so that the operator starts processing the next tree after the fatality so that the time required for the machine to move pass the fatality is recorded as the processing time on the next tree.

Step 3A. Block 21 records clock time in savex 101. Blocks 86 and 87 simulate the time required by the operator to identify the next tree, estimate the D.B.H., and set the shear opening range.

Step 4A. Block 88 simulates the time required for the operator to determine if the tree is a harvestable tree or a defective tree. This block also routes the transaction to step 5A if the tree is a defective tree that must be cut out of the way or to step 6A if the tree is a harvestable tree.

Step 5A. Block 91 sets savex 106 equal to 1111 so that defective trees are identified in the printout data.

Step 6A. Block 89 sets savex 106 equal to 0 so that harvestable trees are identified in the printout data. Block 22 simulates the time for the operator to determine the terrain classification and program the grapple for the terrain slope.

Step 7A. Block 23 records clock time in savex 102. Relative to the value of parameter 8, block 24 routes the transaction to step 8A if a thinning operation is required or to step 9A if a clear-cutting operation is required.

Step 8A. Blocks 92, 93, and 94 simulate the operator, in conjunction with the shear (blocks 142, 143, and 144 of step 4B), determining and accomplishing the slue of the shear to a neutral position so that the harvester can move to the next tree to be removed in a thinning operation.

Step 9A. Block 95 holds the operator and block 146 of step 5B holds the shear for mutual availability. Block 25 records the clock time in savex 103. Blocks 96, 97, and 98 simulate the operator in coordination with the shear (blocks 151, 152, 153, 154, 155, and 156 of step 10B) as he is determining and accomplishing, if necessary, a back up in order to provide clearance for the shear to slue to the tree. Blocks 99, 100, and 101 simulate the operator in coordination with the shear (blocks 157, 158, 159, 160, and 161 of step 10B) as he is determining and accomplishing, if necessary, the initial forward advance to position the machine so that the tree will be near the shear when the shear is slued into alignment with the tree. Blocks 102 and 103 simulate the operator, in coordination with the shear (blocks 162, 163, 164, and 165 of step 10B) as he is controlling the slue of the shear into alignment with the tree. Block 104 holds the operator simulation until the shear has completed the slue to the tree (block 167 of step 11B).

Step 10A. Block 105 simulates the operator preparing for the final advance. Block 106 holds the shear (block 168 of step 12B) until the operator is prepared for the final advance. If the new tree is within 2.5 feet alignment of the shear's neutral position during the final advance, the new tree could interfere with the previous tree that is being processed through steps 9C to 13C by the grapple. In the event of possible interference, the operator and shear simulations are not allowed to pass block 40 of step 13B until the grapple has passed step 13C which is indicated by the value of savex 30.

Block 107 simulates the operator in conjunction with the shear (blocks 169, 170, 171, 172 of step 14B) as he is accomplishing the final forward advance of the harvester to position the shear on the tree. Block 26 records the clock time.

<u>Step 11A</u>. Blocks 27, 28, and 29 compute operating times for the operator. Block 30 prints out operator processing data in savexes 100 to 109 as follows:

(1) Savex 100 records the tree number.

(2) Savex 101 records the time the operator starts processing the tree.

(3) Savex 102 records the time the operator starts waiting on the shear.

(4) Savex 103 records the time when the shear is available to the operator.

(5) Savex 104 records the time when the operator completes processing of the tree.

(6) Savex 105 records the actual operating time of the operator.

(7) Savex 106 identifies defective trees by a value of 1111,

harvestable trees by a value of 0, and fatalities by a value of 1.

(8) Savex 107 is not used to record data.

(9) Savex 108 records the time the operator waits on shear availability.

(10) Savex 109 records the total time required by the operator to process the tree.

After printing the above information, the operator simulation is released by block 108 to simulate processing of the next tree.

Shear Simulation Subprogram

Step 1B. This step is for simulation model logic relative to tree grade identified in parameter 6. Block 35 routes the transaction to step 2B if the tree is a fatality or to step 3B if the tree is a defective tree or a harvestable tree.

Step 2B. This step simulates the shear processing a fatality which actually does not require operating time. Blocks 111, 112, 113, 114, 115, 116, 117, 118, 119, and 46 record the same clock time in savexes 111, 112, 113, 114, 116, 117, 118, 120, 122, and 123. A fatality can be identified in the printout by the same clock time in these savexes and 0 shear operating time. The model is programmed so that the time required for the shear and harvester to move past the tree fatality is recorded as processing time for the next tree.

Step 3B. Block 36 records simulation clock time in savex 111 and provides model logic relative to the type of cutting operation identified in parameter 8. If a thinning cut is being performed, the transaction is routed to step 4B or if clear cutting is being performed, the transaction is routed to step 5B.

Step 4B. Blocks 140 and 141 compute shear slue distance to the neutral position. Blocks 142, 143, and 144 in conjunction with blocks 92, 93, and 94 of step 8A simulate the shear being controlled by the operator and sluing to the neutral position. Block 145 records the shear position in savex 11.

Step 5B. Block 146 holds the operator (block 95 of step 9A) until the shear has completed the slue to the neutral position if a thinning operation is being performed. If clear cutting is being performed, block 146 holds the shear and the operator (block 95 of step 9A) for mutual availability. Block 37 records the clock time in savex 112. The next steps (6B, 10B, and 8B or 9B) are conducted simultaneously.

Step 6B. Block 149 simulates the shear opening time.

Step 7B. Block 197 provides model logic relative to tree grade identified in parameter 6. If the tree is a defective tree, the transaction is routed to step 8B. If the tree is a harvestable tree, the transaction is routed to step 9B.

Step 8B. Block 38 sets savex 121 equal to 1111 so that defective trees are identified in the printout.

Step 9B. Block 39 sets savex 121 equal to 0 so that harvestable trees are identified in the printout. Block 150 simulates the time required for the harvester to automatically set the shear terrain stop.

Step 10B. Blocks 151, 152, 153, 154, and 156 in conjunction with the operator (blocks 96, 97, and 98 of step 9A) simulate the time required to determine and accomplish, if necessary, a back up to provide clearance for the slue of the shear to the tree. Block 155 records the harvester position in savex 10. Blocks 157, 158, 159, and 161 in conjunction with the operator (blocks 99, 100, and 101 of step 9A) simulate the time required to determine and accomplish, if necessary, the initial forward advance to position the machine and shear so that the tree will be near the shear when the shear is slued into alignment with the tree. Block 160 records the harvester position in savex 10. Blocks 162, 163, 164, and 165 in conjunction with the operator (blocks 102 and 103 of step 9A) simulate the time for the slue of the shear into alignment with the tree.

Step 11B. Block 166 holds the shear until steps 6B, 10B, and 8B or 9B are accomplished. Block 198 sets savex 20 equal to 10 to provide clearance (block 235 of step 1C) for grapple slue to the tree. Block 167 holds the operator (block 104 of step 9A) until the shear has completed the slue to the tree.

Step 12B. Block 168 holds the shear until the operator (block 106 of step 10A) is prepared for the final forward advance to position the shear on the tree. Block 168 also provides model logic. If the new tree is within 2.5 feet alignment of the shear's neutral position during the final advance, the new tree could interfere with the previous tree in the grapple that is processing through steps 9C to 13C. If the new tree is in this interference zone, block 168 routes the transaction to step 13B to hold the final advance until there is no danger of interference. If the new tree is not in the interference zone, block 168 routes the transaction to step 14B.

Step 13B. Block 196 records the clock time in savex 113. Block 40 holds the final advance of the shear and harvester until the grapple completes steps 9C through 13C (indicated by value of savex 30) with the previous tree. Block 41 records the clock time in savex 114.

Step 14B. Blocks 169, 170, and 172 in conjunction with the operator (block 107 of step 10A) simulate the final forward advance of the shear and harvester to position the shear on the tree. Block 171 records the harvester's position in savex 10. The shear has a sensor (shear terrain stop) that automatically stops the machine when the tree hits it. Block 172 releases the operator (block 107 of step 10A) to start processing the next tree.

Step 15B. Block 173 simulates the time required for the shear to automatically lower to the ground. Block 173 also provides model logic relative to tree grade identified by parameter 6 of the transaction. The transaction is routed to step 16B if the tree is a defective tree or to step 17B if the tree is a harvestable tree.

Step 16B. Block 174 simulates the time to shear the defective tree and block 175 simulates the time for the defective tree to fall to the ground. Block 176 records the shear position in savex 11 for model reference.

Step 17B. Block 200 simulates the time for the shear to accomplish phase 1 shearing which is the partial severing of the tree stem. Block 42 records clock time in savex 116.

Step 18B. Block 201 holds phase 2 shearing until the grapple is ready to grasp the tree (block 246 of step 4C).

Step 19B. Block 43 records clock time in savex 116. Block 199 sets savex 20 equal to 5 to hold the grapple slue to the tree (block 235 of step 1C) for the next tree until the shear completes the slue to the tree. Block 202 simulates the time to accomplish phase 2 shearing to sever the tree stem. Block 203 holds the grapple (block 248 of step 5C) until the tree is severed. Block 44 records clock time in savex 120.

Step 20B. Block 204 holds the raising of the shear until the grapple raises the tree to the slue position (block 255 of step 8C). Block 45 records the clock time in savex 122. Block 205 simulates the time to raise the shear. Block 206 records the shear position in savex 11 for model reference. Block 46 records the clock time in savex 123.

Step 21B. Blocks 47, 48, and 49 compute time operating data for the shear. Block 110 prints out shear processing data in savexes 110 to 124 as follows:

(1) Savex 110 records the tree number.

(2) Savex 111 records the time when the shear starts to slue to the neutral position.

(3) Savex 112 records the time the shear completes the slue to the neutral position.

(4) Savex 113 records the time the shear starts to wait for grapple clearance if the new tree is within 2.5 feet of alignment with the neutral position.

(5) Savex 114 records the time the shear receives clearance from the grapple.

(6) Savex 115 records the actual operating time of the shear.

(7) Savex 116 records the time when phase 1 shearing is complete.

(8) Savex 117 records the time when clearance is given for the phase 2 shearing.

(9) Savex 118 records the time the shear waits on the operator and grapple availability.

(10) Savex 119 records the total time required for the shear to

process the tree.

(11) Savex 120 records the time when phase 2 shearing is complete.

(12) Savex 121 identifies defective trees by a value of 1111 and harvestable trees by a value of 0. A fatality has a 0 or 1111 value in this savex, but it is identified by a value of 0 for all operating times or the same clock times in savexes 111, 112, 113, 114, 116, 117, 118, 120, 122, and 123.

(13) Savex 122 records the time the shear is given clearance to raise.

(14) Savex 123 records the time the raising of the shear is complete.

(15) Savex 124 is not used to record data.

After printing the above information, the shear simulation is released by block 210 to simulate processing of the next tree.

Grapple Simulation Subprogram

Step 1C. Block 461 records the clock time in savex 131. Block 235 holds the grapple slue to the tree until the shear has slued to the tree (block 198 of step 11B). The grapple is released when savex 20 is set equal to 10 by block 198. Block 462 records clock time in savex 132. Blocks 238, 239, and 240 simulate the time for the grapple to slue to the tree. Block 241 simulates the time to unfold the grapple assembly 60 degrees from under the grapple arm. The next steps (2C and 3C) are performed simultaneously.

Step 2C. Block 243 simulates the time to unfold the grapple assembly the remaining 30 degrees so that it is perpendicular to the grapple arm.

Step 3C. Block 244 simulates the time to lower the grapple arm from the slue position to a position to grasp the tree.

<u>Step 4C</u>. Block 463 records the clock time in savex 133. Block 246 holds the phase 2 shearing (block 201 of step 18B) until the grapple is positioned to grasp the tree. Block 464 records the clock time in savex 134.

<u>Step 5C</u>. Block 247 simulates the time for the grapple to close on the tree. Block 248 holds the grapple until the phase 2 shearing (block 203 of step 19B) is complete and severs the stem. Block 249 simulates the time to raise the grapple and the tree through 10 degrees of the grapple arm. The next steps (6C, 7C, and 8C) are simultaneously performed.

<u>Step 6C</u>. Block 253 simulates the time required to position the tree support on the top of the grapple in order to help support the tree.

<u>Step 7C</u>. Block 252 simulates the time required to rotate the tree and grapple assembly up 15 degrees. This rotation is necessary to position the tree so that it will not interfere with the previous tree that is being processed by the delimber.

<u>Step 8C</u>. Block 254 simulates the time to raise the grapple arm 20 degrees to the slue position. Block 255 holds the raising of the shear (block 204 of step 20B) until the grapple arm is raised to the slue position.

<u>Step 9C</u>. Block 257 sets savex 30 equal to 5 to hold the final advance of the shear (block 40 of step 13B) to avoid interference with the next tree if it is located within 2.5 feet of the shear's neutral position. Block 258 simulates the time to slue the tree and the grapple to the center slue position where it waits for clearance to go to the

delimber holding position. Block 465 records clock time in savex 136.

Step 10C. Block 260 holds the grapple in the center slue position for the delimber clearance (block 315 of step 3D) to go to the delimber holding position. The grapple cannot go to the delimber holding position while the previous tree is processed through steps 1D to 3D because the trees will interfere with each other. The delimber holds the grapple at block 260 by setting savex 35 equal to 5 at block 304 in step 1D. Block 466 records the clock time in savex 137. The next steps (11C and 12C) are simultaneously performed.

Step 11C. Block 262 simulates the time required to rotate the grapple assembly and tree support 15 degrees so that the tree is 90 degrees to the grapple arm.

Step 12C. Block 263 simulates the time to rotate the grapple arm 30 degrees to the delimber holding position.

Step 13C. Block 265 sets savex 30 equal to 10 to release the shear for the final advance for the next tree (block 40 of step 13B). Block 467 records the clock time in savex 140. Block 266 holds the grapple in the delimber holding position until the delimber is clear to receive the tree (block 302 of step 1D). Block 468 records clock time in savex 142.

Step 14C. Block 267 simulates the time to rotate the grapple arm down 30 degrees and lower the tree into the delimber. Block 268 simulates the time to open the grapple. Block 269 holds the delimber receiver (block 303 of step 1D) until the grapple is opened. Block 270 holds the grapple for the delimber receiver to raise the tree off the grapple (block 306 of step 1D). The next steps (15C, 16C, 17C, and 18C) are conducted simultaneously.

Step 15C. Block 272 simulates the time to lower the grapple arm 30 degrees to the delimber holding position.

Step 16C. Block 274 simulates the time to fold the tree support back on the grapple arm.

Step 17C. Block 276 simulates the time to lower the grapple arm 30 degrees to the center slue position.

Step 18C. Block 275 simulates the time to fold the grapple assembly 90 degrees under the grapple arm.

Step 19C. Block 278 holds the lowering of the delimber receiver (block 307 of step 2D) until the grapple has been lowered out of the way of the tree. Block 469 records the clock time in savex 143.

Step 20C. Blocks 470, 471, and 472 compute operating data for the grapple. Block 473 prints out grapple processing data in savexes 130 to 144 as follows:

(1) Savex 130 records the tree number.

(2) Savex 131 records the time when the grapple is ready to slue to the tree.

(3) Savex 132 records the time when the grapple receives clearance to slue to the tree.

(4) Savex 133 records the time when the grapple is in position for the phase 2 shearing to start.

(5) Savex 134 records the time when phase 2 shearing starts.

(6) Savex 135 records the actual operating time of the grapple.

(7) Savex 136 records the time the grapple starts waiting for clearance to go to the delimber holding position.

(8) Savex 137 records the time the grapple receives clearance to go to the delimber holding position.

(9) Savex 138 records the total time the grapple waits on the shear and delimber.

(10) Savex 139 records the total time required for the grapple to process the tree.

(11) Savex 140 records the time when the grapple starts waiting in the delimber holding position.

(12) Savex 141 is not used to record data.

(13) Savex 142 records the time when the grapple receives delimber clearance to receive the tree.

(14) Savex 143 records the time when the grapple completes the processing of the tree.

(15) Savex 144 is not used to record data.

After printing the above information, the grapple simulation is released by block 282 to simulate processing of the next tree.

Delimber Simulation Subprogram

Step 1D. Block 481 records the clock time in savex 151. Block 302 holds the delimber and block 266 of step 13C holds the grapple for mutual availability. Block 482 records the clock time in savex 152. Block 303 holds the delimber receiver until the grapple has opened (block 269 of step 14C). Block 304 sets savex 35 equal to 5 to hold the grapple at the center slue position (block 260 of step 10C) when it processes the next tree to avoid interference with this tree. Block 305 simulates the time for the delimber receiver to lift the tree clear of the grapple. Block 306 holds the grapple (block 270 of step 14C) until the receiver lifts the tree clear of the grapple.

Step 2D. Block 307 holds the delimber receiver until the grapple (block 278 of step 19C) is lowered out of the way. Block 308 simulates the time for the delimber receiver to lower the tree into the delimber. Block 309 simulates the time for closing the delimber tree retaining arms. Block 310 simulates the time for the delimber to rotate the tree against the delimbing cutters to remove the limbs. Block 311 simulates the time for the tree retaining arms to open. Block 483 records the clock time in savex 153.

Step 3D. Block 312 holds the delimber and block 367 of step 13E holds the bucker for mutual availability to flip the tree from the delimber into the bucker. Block 484 records the clock time in savex 154. Block 314 simulates the time for the delimber discharge flips to flip the tree into the bucker. Block 315 sets savex 35 equal to 10 to allow the grapple (block 260 of step 10C) to move from the center slue position to the delimber holding position. Block 316 holds the bucker receiving flips (block 368 of step 13E) until the delimber discharging flips have discharged the tree. Block 317 holds the delimber discharge flips until the bucker receiving flips receive the tree (block 371 of step 14E). Block 318 simulates the time to return the bucker discharge flips. Block 485 records the clock time in savex 156.

Step 4D. Blocks 486, 487, and 488 compute operating data for the delimber. Block 489 prints out the delimber processing data in savexes 150 to 159 as follows:

(1) Savex 150 records the tree number.

(2) Savex 151 records the time when the delimber is ready to

receive another tree.

(3) Savex 152 records the time when the grapple starts lowering the tree into the delimber.

(4) Savex 153 records the time when the delimber starts waiting for the bucker clearance.

(5) Savex 154 records the time when the delimber starts discharging the tree into the bucker.

(6) Savex 155 records the actual operating time of the delimber.

(7) Savex 156 records the time the delimber completes processing of the tree.

(8) Savex 157 is not used to record data.

(9) Savex 158 records the time the delimber waits on the grapple and bucker.

(10) Savex 159 records the total time required for the delimber to process the tree.

After printing the above information, the delimber simulation is released by block 319 to simulate processing of the next tree.

Bucker Simulation Subprogram

Step 1E. Blocks 342 through 349 assign savexes 41 through 48 the value of parameters 1 through 8 for the tree transaction. This is necessary because parameters will be changed for programming purposes in this subprogram. Block 350 assigns parameter 2 logic values for programming logic. If the tree height is 65 to 80 feet, a value of 10 is assigned parameter 2. If the tree height is not 65 to 80 feet, a value of 0 is assigned parameter 2. Trees 65 to 80 feet high require the rear shear and the rear set of bucker discharge flips to be turned down.

This is necessary so the tree top and top bolt are flipped on the ground. The harvester can process only 50 feet of a tree. Trees over 65 feet normally have a merchantable length over 50 feet. The harvester cannot process the short tops on 65 to 80 foot trees, but it can process the remaining merchantable wood in the top if the last bolt is left on the top. In view of this, the harvester is normally recycled to process the top bolt and the remaining wood in the top. For trees not 65 to 80 feet long, the rear shear and rear set of discharge flips are turned up so the top bolt is flipped into the conveyer and the top falls on the ground. Blocks 351, 500, and 352 assign parameter 3 logic values to provide model logic that determines if the rear shear and flips are changed for this tree. The parameter 2 value for the previous tree is recorded in savex 50. The parameter 2 value of this tree is compared to that of the previous tree. If a change is required for this tree, parameter 3 is assigned a value of 10 and if no change is required, parameter 3 is assigned a value of 0. Block 501 records the clock time in savex 161. The next steps (2E, 3E, 4E, and 6E) are conducted simultaneously.

Step 2E. Block 364 simulates the time to return all discharging flips except the rear bucker discharging flips.

Step 3E. Block 366 simulates the time to position the bucker shears to allow for expansion during the simultaneous shearing action.

Step 4E. Block 410 provides model logic based on the value assigned parameter 3 in step 1E. If repositioning of the rear shear is required (parameter 3 equals 10), the transaction is routed to step 5E. If no change is required (parameter 3 equals 0), the transaction is routed directly to step 13E.

Step 5E. Block 363 simulates the time to reposition the rear shear up or down.

Step 6E. Block 409 provides model logic based on the value assigned parameter 3 in step 1E. The transaction is routed to step 7E if repositioning of the rear set of discharging flips is not required (parameter 3 equals 0). The transaction is routed to step 10E if repositioning of the rear set of discharging flips is required (parameter 3 equals 10).

Step 7E. Block 356 provides model logic based on the value assigned parameter 2 in step 1E. If the tree is 65 to 80 feet high (parameter 2 equals 10), the transaction is routed to step 8E. If the tree is not 65 to 80 feet high (parameter 2 equals 0), the transaction is routed to step 9E.

Step 8E. Block 357 simulates the time to return the rear set of bucker receiving flips.

Step 9E. Block 358 simulates the time to return the rear set of bucker discharging flips.

Step 10E. Block 359 provides model logic based on the value assigned parameter 2 in step 1E. If the tree is 65 to 80 feet high (parameter 2 equals 10), the transaction is routed to step 11E. If the tree is not 65 to 80 feet high (parameter 2 equals 0), the transaction is routed to step 12E.

Step 11E. Block 360 simulates the time to return the bucker rear set of discharge flips. Block 361 simulates the time to rotate the rear set of discharge flips down.

Step 12E. Block 362 simulates the time to return the rear receiving flips and rotate the bucker discharge flips up.

Step 13E. Block 502 records clock time in savex 162. Block 367 holds the bucker and block 312 of step 3D holds the delimber discharge of the tree for mutual availability. Block 503 records the clock time in savex 163. Block 368 holds the bucker receiving flips for the delimber discharging flips to discharge the tree (block 316 of step 3D). Block 369 simulates the time for the bucker receiving flips to flip the tree into the bucker.

Step 14E. Block 371 holds the return of the delimber discharge flips (block 317 of step 3D) for the bucker receiving flips to receive the tree. Block 372 simulates the time for the shears to shear the tree into bolts. The next steps (15E and 16E) are performed simultaneously.

Step 15E. Block 374 simulates the time required to open the shears.

Step 16E. Block 375 simulates the time to return the bucker receiving flips.

Step 17E. Block 504 records the clock time in savex 164. Block 377 holds the bucker discharge flips for the conveyer clearance (block 531 of step 7F) when it completes processing the previous tree. Conveyer clearance is indicated by savex 180 being assigned a value of 0 at block 531 of step 7F as the previous tree is processed through the conveyer. Block 505 records the clock time in savex 166. The next steps (18E and 19E) are simultaneously performed.

Step 18E. Block 380 simulates the time to flip the front and middle bolts into the conveyer.

Step 19E. Block 411 provides model logic based on the values assigned parameter 2 in step 1E. If the tree is not 65 to 80 feet high (parameter 2 equals 0), the transaction is routed to step 20E. If the tree is 65 to 80 feet high (parameter 2 equals 10), the transaction is routed to step 21E.

Step 20E. Block 379 simulates the time for the rear set of discharge flips to flip the rear tree bolt into the conveyer.

Step 21E. Block 381 simulates the time for the rear receiving flips to flip the rear bolt and tree top on the ground.

Step 22E. Block 383 assigns savex 50 the value of parameter 2 for reference in step 1E for the next tree when the logic value of parameter 3 is computed. Block 398, 399, 400, 401, 402, and 403 reassign original values to parameters 1, 2, 3, 6, 7, and 8. Block 506 records the clock time in savex 506. Blocks 507, 509, and 510 compute operating data for the bucker. Block 511 prints out the bucker processing data in savexes 160 to 169 as follows:

(1) Savex 160 records the tree number.

(2) Savex 161 records the time when the bucker starts preparing to process the next tree.

(3) Savex 162 records the time when the bucker starts waiting on the delimber.

(4) Savex 163 records the time when the delimber starts discharging the tree into the bucker.

(5) Savex 164 records the time when the bucker starts waiting on the conveyer.

(6) Savex 165 records the actual operating time of the bucker.

(7) Savex 166 records the time when the bucker starts flipping the bolts into the conveyer.

(8) Savex 167 records the time when the bucker completes the processing of the tree.

(9) Savex 168 records the time the bucker waits on the delimber and conveyer.

(10) Savex 169 records the total time required for the bucker to process the tree.

After printing the above information, the bucker simulation is released by block 416 to simulate processing of the next tree.

Conveyer Simulation Subprogram

Step 1F. Block 532 sets savex 180 equal to 10 so that the bucker cannot discharge the next tree into the conveyer while this tree is being processed. Block 526 records the clock time in savex 171. The next steps (2F, 3F, 4F, 5F, and 6F) are performed simultaneously.

Step 2F. Block 428 simulates the time to convey the top bolt to the conveyer stop and block 429 simulates the time to stop the bolt. Block 430 simulates the time to open the conveyer side gate. The rear section of the conveyer (section above the storage grapple) is tilted to the side so the bolts will fall off the conveyer when the side gate is opened. Block 431 simulates the time for the bolt to fall out of the conveyer and block 432 simulates the time to close the conveyer side gate.

Step 3F. Block 433 delays conveying of the middle bolt to provide the top bolt conveyer clearance.

Step 4F. Block 434 simulates the time to convey the middle bolt to the stop and block 435 simulates the time to stop the bolt. Block 436 simulates the time to open the conveyer side gate and block 437 simulates the time for the middle bolt to fall out of the conveyer.

Block 438 simulates the time to close the conveyer side gate.

Step 5F. Block 439 delays conveying of the bottom bolt for the middle bolt conveyer clearance.

Step 6F. Block 440 simulates the time to convey the bottom bolt to the conveyer stop and block 441 simulates the time to stop the bottom bolt. Block 442 simulates the time to open the conveyer side gate and block 443 simulates the time for the bottom bolt to fall out of the conveyer. Block 444 simulates the time to close the conveyer side gate.

Step 7F. Block 531 sets savex 180 equal to 0 to provide the conveyer clearance for the bucker (block 377 of step 17E) to start flipping bolts into the conveyer. Block 446 simulates the time to tilt the conveyer rotatable section (section above the storage grapple) to the other side so as to provide even loading of the storage grapple. Block 527 records the clock time in savex 172.

Step 8F. Blocks 528 and 529 compute the operating data for the conveyer. Block 530 prints out the conveyer processing data in savexes 170 to 179 as follows:

(1) Savex 170 records the tree number.

(2) Savex 171 records the time when the conveyer starts processing the tree.

(3) Savex 172 records the time when the conveyer completes processing the tree.

(4) Savex 173 is not used to record data.

(5) Savex 174 is not used to record data.

(6) Savex 175 records the actual operating time of the conveyer.

(7) Savex 176 is not used to record data.

(8) Savex 177 is not used to record data.

(9) Savex 178 is not used to record data.

(10) Savex 179 records the total time required for the conveyer to process the tree.

After printing the above information, the conveyer simulation is released by block 450 to simulate processing of the next tree.

Program Termination

The simulation model is designed to process 105 trees through block 76 and then run for an additional 1,800 simulation time units (180 seconds) before terminating the simulation. Blocks 452, 453, 454, and 455 provide model termination control.

The purpose of this model is to determine the basic processing time per tree relative to tree and forest characteristics. The basic processing time is used by the economical model to compute the time required to process a grapple load for the specific tree and forest characteristics being considered by the economic model. The economic model determines the unloading time. The economic model then determines the total harvester time per load from the sum of the unloading time and the load processing time.

CHAPTER VI

HARVESTER SIMULATION MODEL EXPERIMENTATION AND RESULTS

A simulated small sample forest of 100 trees is developed for simulated harvesting by the harvester model. Initial planting density, survival rate, and tree size of the simulated forest are varied for multiple harvester simulations by the harvester model. The results are used to determine the harvester's processing time per harvestable tree relative to various values of these tree and forest characteristics.

A simulated forest (100 trees) is developed by first randomly identifying harvestable trees at .80, .75, .70, and .65 survival levels. The defective trees and fatalities are increased progressively so that the trees that are defective trees or fatalities, at a higher survival level, are also defective trees or fatalities at the lower survival levels. Additional harvestable trees are randomly identified as defective trees or fatalities as survival decreases. The defective trees are estimated to be 20 percent of the number of defective trees and fatalities. The progressive method of increasing defective trees and fatalities is necessary to maintain a common base on which to compare processing time as survival decreases. The resulting simulated forest tree grade sequence is presented in Table 1. One of these survival sequences (.80, .75, .70, or .65), depending on survival level desired for a simulation run, is coded in function 6 of the simulation model and used by block 8 of step 1 to assign tree grades to parameter 6 of each tree transaction.

Table 1. Simulated Sample Forest Tree Grade Sequence

Tree Number	Tree Grade Relative to Survival Level				Tree Number	Tree Grade Relative to Survival Level			
	.80	.75	.70	.65		.80	.75	.70	.65
1	G	G	G	G	26	G	M	M	M
2	G	G	G	G	27	G	G	G	G
3	M	M	M	M	28	G	G	G	G
4	G	G	G	G	29	G	G	G	G
5	G	G	G	G	30	G	G	G	G
6	C	C	C	C	31	G	G	G	G
7	G	G	G	G	32	G	G	G	G
8	G	G	G	G	33	G	G	G	G
9	G	G	G	G	34	G	G	G	G
10	G	G	G	G	35	M	M	M	M
11	G	G	G	G	36	G	G	G	G
12	G	G	G	G	37	G	G	G	G
13	G	G	G	G	38	G	G	G	G
14	G	G	G	M	39	C	C	C	C
15	M	M	M	M	40	M	M	M	M
16	M	M	M	M	41	G	G	M	M
17	G	G	G	G	42	M	M	M	M
18	G	M	M	M	43	G	G	G	G
19	G	G	G	G	44	G	G	G	G
20	G	G	G	G	45	G	G	G	G
21	G	G	G	G	46	G	G	G	G
22	G	G	G	G	47	M	M	M	M
23	G	G	G	G	48	G	G	G	G
24	G	G	G	G	49	G	G	M	M
25	G	G	G	G	50	G	G	G	G

G is a Harvestable Tree.
C is a Defective Tree.
M is a Tree Fatality

Table 1. Simulated Sample Forest Tree Grade Sequence (Continued)

Tree Number	Tree Grade Relative to Survival Level				Tree Number	Tree Grade Relative to Survival Level			
	.80	.75	.70	.65		.80	.75	.70	.65
51	M	M	M	M	76	G	G	G	C
52	G	G	G	G	77	M	M	M	M
53	G	G	G	G	78	G	G	G	G
54	M	M	M	M	79	G	G	G	G
55	G	G	G	G	80	G	G	G	G
56	C	C	C	C	81	G	G	G	G
57	G	G	G	G	82	G	G	G	G
58	G	G	G	M	83	G	G	G	G
59	G	G	G	G	84	G	G	G	G
60	G	G	G	G	85	M	M	M	M
61	G	G	M	M	86	G	G	G	G
62	G	G	G	G	87	M	M	M	M
63	G	G	G	G	88	G	M	M	M
64	C	C	C	C	89	G	C	C	C
65	G	G	G	G	90	G	G	G	G
66	M	M	M	M	91	G	G	C	C
67	G	G	G	G	92	G	G	G	G
68	G	G	M	M	93	G	M	M	M
69	G	G	G	M	94	M	M	M	M
70	G	G	G	G	95	G	G	G	G
71	M	M	M	M	96	G	G	G	M
72	G	G	G	G	97	M	M	M	M
73	G	G	G	G	98	G	G	G	G
74	G	G	G	G	99	G	G	G	G
75	G	G	G	G	100	G	G	G	G

A 100 tree sample forest (initial planting quantity) or multiples of 100 trees is necessary because the number of defective trees and fatalities are integers for multiples of 100 trees (initial planting quantity) at the survival levels considered. The simulation is not designed to handle fractions of trees. Only one random sample at specific survival levels is used. Insignificant changes in harvestable tree processing time is assumed to occur at different distributions of defective trees and fatalities at specific survival levels. This assumption is based on the fact that basicly the same processing movements are required at a specific survival level and only the sequence of movements is changed by changes in distribution at a specific survival level.

A set of harvester simulation runs with the simulated forest is run with 5 inch D.B.H. trees. These runs are made for initial planting densities of 200 to 1,000 trees per acre. The trees are oriented in a square pattern and the initial planting densities are changed in 100 trees per acre increments. Simulation runs are then made at 65, 70, 75, and 80 percent survival levels for each of the initial planting densities. The processing time, per harvestable tree for each simulation, is computed by dividing the survival level into the simulation clock time (savex 172 for tree 100) when processing is completed on tree number 100. This gives the cycle time in tenths of seconds. The value of savex 172 for tree number 100 must have 10 subtracted from it before the above division is accomplished. This accounts for a 1 second delay by block 1 of step 1 to insure model control. The resulting processing times are plotted for each planting density as a function of survival. The graphs are projected to .50 and 1.00 survival levels. The resulting processing times, relative to initial planting density and survival for 5 inch D.B.H. trees, are presented in Table 2.

A set of harvester simulation runs is then made for 700 trees per acre (initial planting density) for trees with 6, 7, 8, 9, and 10 inch D.B.H.s at .80, .75, .70, and .65 survival levels. The results are used as above to compute harvester processing time relative to D.B.H. and survival for initial planting density of 700 trees per acre. The processing times per harvestable tree are interpolated to 4 and 12 inch D.B.H.s. The resulting processing times are used to determine correctional values that can be used to adjust the 5 inch D.B.H. processing time (Table 2) to account for different D.B.H.s in four survival ranges. The resulting correctional time values are presented in Table 3.

It is assumed that these correctional time values can be used uniformly for all planting densities. Simulation runs at 200 to 1,000 trees per acre (initial planting densities) are made for 7.5 inch D.B.H. at .75 survival, 10 inch D.B.H. at .75 survival, and 10 inch D.B.H. at .65 survival to determine if large errors result by uniformly using the correctional time values. The results are presented in Table 4. Only small errors result; therefore, the processing time (relative to initial planting density and survival) for 5 inch D.B.H. trees (Table 2) and the correctional time values for other D.B.H.s (Table 4) are used to summarize the harvester processing time per harvestable tree for use by the economic model.

Preliminary economic analysis indicate optimal tree heights are not much over 65 feet. It is estimated that 65 foot high trees have a 50 foot merchantable stem below the 3 inch top diameter. The harvester

Table 2. Harvester Processing Time (in Seconds) for 5 Inch Diameter at Breast Height Harvestable Trees Relative to Planting Density and Survival

Survival Per-centages	Initial Planting Densities (Trees per Acre) 200	300	400	500	600	700	800	900	1000
100	17.0	15.6	14.9	14.5	14.0	13.7	13.5	13.3	13.2
95	17.6	16.2	15.4	14.9	14.4	14.1	13.9	13.7	13.6
90	18.3	16.8	16.0	15.4	14.9	14.6	14.3	14.1	13.9
85	19.0	17.4	16.5	15.9	15.4	15.0	14.7	14.5	14.3
80	19.888	18.201	17.198	16.503	15.984	15.585	15.289	15.020	14.821
75	20.698	18.900	17.827	17.088	16.536	16.108	15.791	15.505	15.292
70	21.583	19.691	18.540	17.750	17.160	16.701	16.359	16.054	15.284
65	22.612	20.600	19.371	18.523	17.886	17.395	17.023	16.697	16.446
60	23.9	21.7	20.3	19.4	18.6	18.1	17.7	17.4	17.1
55	25.4	23.0	21.4	20.5	19.6	19.1	18.7	18.3	18.0
50	27.2	24.5	22.6	21.7	20.6	20.1	19.6	19.2	18.9

Table 3. Harvester Processing Time Correctional Time Values (in seconds) Relative to Diameter at Breast Height

	Survival Ranges			
D.B.H.	Less than .675	Equal to or Greater than .675 and Less than .725	Equal to or Greater than .725 and Less than .775	Equal to and Greater than .775
4	-0.354	-0.343	-0.333	-0.325
5	+0.000	+0.000	+0.000	+0.000
6	+0.354	+3.343	+0.333	+0.325
7	+0.817	+0.795	+0.775	+0.758
8	+1.179	+1.145	+1.115	+1.089
9	+1.539	+1.493	+1.453	+1.419
10	+2.433	+2.369	+2.313	+2.265
11	+3.327	+3.245	+3.173	+3.111
12	+4.221	+4.121	+4.033	+3.957

Table 4. Harvester Processing Times Determined by Simulation Model versus Processing Times Computed with Correctional Time Values

Initial Planting Densities (Trees per Acre)	Processing Time (Seconds per Harvestable Tree) Based on Simulation Model	Processing Time (Seconds per Harvestable Tree) Based on Correctional Time Values	Error (Seconds per Harvestable Tree)
	7.5 Inch D.B.H. and .75 Survival		
200	21.586	21.643	.157
300	19.789	19.845	.056
400	18.717	18.772	.055
500	17.979	18.033	.054
600	17.427	17.481	.044
700	16.999	17.053	.054
800	16.681	16.736	.055
900	16.396	16.450	.054
1000	16.183	16.237	.054
	10 Inch D.B.H. and .75 Survival		
200	23.012	23.011	.001
300	21.212	21.213	.001
400	20.140	20.140	.001
500	19.401	19.401	.000
600	18.849	18.849	.000
700	18.421	18.421	.000
800	18.104	18.104	.000
900	17.819	17.818	.001
1000	17.605	17.605	.000
	10 Inch D.B.H. and .65 Survival		
200	25.044	25.045	.001
300	23.031	23.033	.002
400	21.803	21.804	.001
500	20.955	20.956	.001
600	20.318	20.319	.001
700	19.828	19.828	.000
800	19.455	19.456	.001
900	19.125	19.130	.005
1000	18.878	18.879	.001

can harvest 50 feet of a tree in a single processing sequence. The harvester must be recycled to harvest more than 50 feet of the tree on trees higher than 65 feet which have merchantable stems longer than 50 feet. For trees slightly higher than 65 feet, little volume is lost in the top above 50 feet and it is not economical to recycle the harvester for this small volume of wood. In view of this, the harvester simulation model is programmed to harvest only 50 feet of the merchantable stem on trees over 65 feet high. The volume lost is accounted for in the economic model. In addition, the harvester processing time is not considered to be affected by tree height if the harvester is not recycled.

It is also necessary to determine the time required to process the last tree of a load. The hydraulic suspension system alerts the operator when 13,000 pounds of wood is supported by the harvester. After being alerted, he starts positioning the harvester to unload the load. While the operator is positioning the harvester, the last tree is automatically being processed by the harvester. The economic model computes the load processing time from the number of trees per load and the processing time per tree as determined by this harvester simulation. The economic model also determines the unloading time. The economic model then computes the total harvester operating time, per load, as a sum of the load processing time and the unloading time. Since the last tree is processed during the unloading time, the processing time on the last tree of the load, after the shear raising, is subtracted from the above sum to determine the correct harvester operating time per load.

The time (in tenths of seconds) required to process the last tree is the difference between savexes 123 and 172 for tree number 106. Savex

123 is the clock time when the raising of the shear is complete. Savex 172 is the clock time when the conveyer completes processing a tree. Diameter is the only characteristic that affects this time. The processing times are computed for D.B.H. values of 5 to 10 inches (in 1 inch increments) and interpolated to 4 and 12 inches. The results are presented in Table 5. These data are used in the economic model.

Table 5. Time Required to Complete Processing of the Last Tree in a Load versus Diameter at Breast Height

D.B.H. (Inches)	Time Required to Complete Processing of the Last Tree in a Load (Seconds)
4	28.2
5	28.2
6	28.2
7	28.2
8	29.3
9	29.7
10	30.2
11	30.73
12	31.32

CHAPTER VII

FOREST GROWTH MODEL

Discussion of the Forest Growth Model

The design of pulpwood harvesting machines and the characteristics of trees and forest being harvester should be highly compatible with each other. Tree and forest characteristics are determined by forest planning and management policies. A forest growth simulation model is developed to determine tree and forest characteristics at harvesting time relative to forest planning and management alternatives. The tree characteristics considered are tree height, D.B.H., weight, and volume. The forest characteristics considered are the forest yield and tree distribution as determined by initial planting densities and survival rates. Forest planning determines the initial planting density and the site index of the land on which the trees are planted. Forest management determines the age at which the forest is harvested. The results of the forest growth model and the harvester simulation model are used by the economic model to economically evaluate the machine design in conjunction with forest planning and management alternatives.

The forest growth model is based on tree growth regression equations developed by Bennett, McGee, and Clutter (16) and tree growth suppression data developed by Nelson, Lotti, Brender, and Trousdell (17). The regression equations were developed from tree growth observed on old-field slash pine plantations in the Georgia Costal Plain and the Carolina

Sandhills. The forest planning and management related to these data are considered representative of future forest planning and management. The regression equations are developed from data gathered from 308 plots as described in Table 6.

A major problem was encountered due to the low ages of the sample plots. The regression equations do not adequately account for growth suppression that occurs at higher tree ages when the trees start saturating the land. The most valuable data relative to growth suppression are found in a technical paper by Nelson, Lotti, Brender, and Trousdell (17) on volume growth in natural loblolly pine stands. This work identifies the square feet of basal area per acre for full stocking relative to D.B.H. and the basal areas for optimal growth rates relative to site index. After a review of the data presented by Nelson, Lotti, Brender, and Trousdell (17), it is assumed that growth suppression begins at the basal areas identified at the maximum growth rates.

The data on natural loblolly pine stands are used to estimate the basal area (relative to D.B.H. and site index) where growth suppression starts. These data are also used to estimate the growth rates subsequent to suppression initiation.

Development of the Forest Growth Model

The forest growth model is programmed in DYNAMO computer language (12). This language is used because of its adaptability for dynamic feedback systems in business, economics, or engineering and its ability to translate mathematical models into tabulated and plotted results.

The economic model requires extensive data from the forest growth

Table 6. Distribution of Sample Plots by Age and Site Index (Age 25)

Age Class	Site Index 30	40	50	60	70	80	Total
10	-	2	2	27	12	2	45
13	-	2	5	22	27	3	59
16	2	1	4	49	47	6	109
19	-	1	10	31	36	1	79
22	-	2	1	9	-	-	12
25	-	-	1	1	1	-	3
28	-	-	-	-	1	-	1
TOTAL	2	8	23	139	124	12	308

model. Also, the forest growth model is closely related to the economic model in that both have the same time base. In view of this, the forest growth model and the economic model are programmed as two sections of a joint model and run simultaneously.

The forest growth model consists of 12 subprograms numbered 1 through 12. The forest growth simulation model and sample printout are contained in Appendix III. The purpose of each subprogram is as follows:

(1) Subprogram 1 assigns values to computational constants.

(2) Subprogram 2 computes time variables used in the model.

(3) Subprogram 3 computes the tree D.B.H.

(4) Subprogram 4 computes the tree height.

(5) Subprogram 5 computes tree survival rates.

(6) Subprogram 6 computes tree basal areas per acre.

(7) Subprogram 7 computes the basal area for the next year when growth suppression occurs.

(8) Subprogram 8 computes the D.B.H. suppression factor when growth suppression occurs.

(9) Subprogram 9 computes the basal area value at which growth suppression occurs.

(10) Subprogram 10 computes the basal area increase during the next computational interval relative to the basal area increase during the past computational interval when growth suppression occurs.

(11) Subprogram 11 computes the unsuppressed basal area at the next computational instant.

(12) Subprogram 12 computes the yield per acre.

Development of each of the forest growth model subprograms is discussed in detail.

Subprogram 1

Certain computational constants are used in many applications in the forest growth model and the economic model. These constants are assigned values by this subprogram.

Computational constants X and P are assigned a value of 1. SITEI is assigned the value of the land site index, based on 25 years, for specific model runs. Computational constant P is used in converting natural logarithms to common logarithms and it is assigned a value of 1/2.3025851.

Subprogram 2

The tree growth model and the economic model are based on time. The tree and forest characteristics are computed at 1 year increments from planting time to 40 years.

The model's basic time variable is N. The variable N is initially set equal to 0 and then increased by 1 between each computational instant. Most model time calculations are based on the variable AGE. AGE is equal to 1 when N is less than 1 or AGE is equal to N when N is equal to 1 or more. AGE is not allowed to be less than 1 because it is used as the divisor in several equations. The computations for N and AGE are summarized below:

```
1L  N.K=N.J+(DT)(+NR-0)
C   NR=1
6N  N=0
7A  N1.K=P+N.K
```

```
        51A  NC.K=CLIP(+0,1,N.K,+1)
        7A   NX.K=N.K+NC.K
        6A   AGE.K=NX.K
```

N.K	=	Value of N for Current Computational Instant
N.J	=	Value of N for Previous Computational Instant
NR	=	Time Increment Value (NR equals one year for this model.)
N1.K	=	Value of N at Next Computational Instant
NC	=	CLIP Function (NC equals 1 when N.K is less than 1 or NC equals 0 when N.K is 1 or greater.)
NX.K	=	N.K or 1 (NX.K equals 1 when N.K is 1 or greater or NX.K equals 1 when N.K is less than 1.)
AGE.K	=	Tree Age at Current Computational Instant

The inverse of AGE is used in the rate of return computations in the economic model. The inverse of AGE is identified as NIV and computed by the following equation:

```
        20A  NIV.K=P/NX.K
```

NIV.K	=	Inverse of AGE
P	=	1 (P is a computational constant established by subprogram 1.)
NX.K	=	N.K or 1

Many computations in the model are computed during the current computational instant for the next computational instant. XAGE is identified as the time variable for computations for the next computational instant. XAGE is computed as follows:

```
        7A   XAGE.K=AGE.K+P
```

XAGE.K	=	Tree Age at Next Computational Instant
AGE.K	=	Tree Age at Current Computational Instant
P	=	1 (P is a computational constant established by subprogram 1.)

Subprogram 3

Prior to growth suppression, D.B.H. is a function of tree age, site index of the land, and surviving trees per acre. The regression equation (16) for unsuppressed D.B.H (DBHT) is as follows:

LogDBHT=0.650712+0.000219(AGE)(SITEI)-0.234544(LogXSTAF)+0.314215(LogSITEI)

The unsuppressed D.B.H. (DBHT) is computed as follows:

```
12A  DBHA1.K=(AGE.K)(SITEI.K)
12A  DBHA.K=(0.000219)(DBHA1.K)
29A  DBHB1.K=(F.K)LOGN(XSTAF.K)
12A  DBHB.K=(0.234544)(DBHB1.K)
29A  DBHC1.K=(F.K)LOGN(SITEI.K)
12A  DBHC.K=(0.314215)(DBHC1.K)
9A   DBHL.K=+0.650712+DBHA.K-DBHB.K+DBHC.K
12A  DBHL1.K=(2.3025851)(DBHL.K)
28A  DBHT.K=(X.K)EXP(DBHL1.K)
```

DBHA1.K	=	Computational Factor for DBHA.K
AGE.K	=	Tree Age (AGE.K is computed by subprogram 2.)
SITEI.K	=	Site Index of the Land (Value of SITEI.K is assigned by subprogram 1.)
DBHA.K	=	Second Term of Regression Equation
DBHB1.K	=	Computational Factor for DBHB.K
F.K	=	1 (F.K is a computational constant established by subprogram 1.)
XSTAF.K	=	Surviving Trees per Acre (Value is computed by subprogram 5.)
DBHB.K	=	Third Term of Regression Equation
DBHC1.K	=	Computational Factor for DBHC.K
DBHL.K	=	Common Logarithm of DBHT
DBHL1.K	=	Natural Logarithm of DBHT
X.K	=	1 (X.K is a computational constant established by subprogram 1.)
DBHT.K	=	Unsuppressed D.B.H. at Current Computational Instant

The variable DBHT does not account for growth suppression. A D.B.H. suppression factor (BASL4) is used to account for growth suppression. The product of BASL4 and DBHT is used to compute DBH. DBH is the value used for all computations requiring the D.B.H. value for current computational instants. DBH is computed by the following equation:

12A DBH.K=(BASL4.K)(DBHT.K)

DBH.K	=	D.B.H. Value for Current Computational Instant
BASL4.K	=	D.B.H. Suppression Factor (BASL4.K is computed by subprogram 8, and it is equal to 1 when suppression does not occur.)
DBHT.K	=	Unsuppressed D.B.H. at Current Computational Instant

Subprogram 4

The tree height is a function of tree age and site index of the land. The regression equation (16) for tree height is presented below:

$$\text{LogHGH}=\text{LogSITEI}+5.40638\left(\frac{1}{25}-\frac{1}{\text{AGE}}\right)$$

The tree height (HGH) is computed as follows:

6A HGHB.K=DBHC1.K
20A HGHA2.K=1/25
20A HGHA3.K=1/AGE.K
7A HGHA1.K=HGHA2.K-HGHA3.K
12A HGHA.K=(5.40638)(HGHA1.K)
7A HGHL.K=HGHB.K+HGHA.K
12A HGHL1.K=(2.3025851)(HGHL.K)
28A HGH.K=(X.K)EXP(HGHL1.K)

DBHB.K	=	First Term of Regression Equation (DBHB.K is equal to DBHC1.K which is computed in subprogram 3.)
HGHA2.K	=	Computational Term for HGHA1
HGHA3.K	=	Computational Term for HGHA1
HGHA1.K	=	Computational Factor for HGHA.K
HGHA.K	=	Second Term of Regression Equation
AGE.K	=	Tree Age (AGE.K is computed by subprogram 2.)
HGHL.K	=	Common Logarithm of Tree Height
HGHL1.K	=	Natural Logarithm of Tree Height
X.K	=	1 (X.K is a computational constant established by subprogram 1.)
HGH.K	=	Tree Height at Current Computational Instant

Subprogram 5

This subprogram estimates tree survival. Limited information is available that provides guidance on survival. Therefore, the following equation was developed to estimate the harvestable surviving trees per acre at yearly increments after planting.

```
52L HSTPA.K=HSTPA.J+(DT)(RTPA.JK-INMR.JK-AMR.JK-MORT1.JK)
```

HSTPA.K	=	Harvestable Surviving Trees per Acre for Current Computational Instant (The initial value of HSTPA is set at 200.)
HSTPA.J	=	Harvestable Surviving Trees per Acre for Prior Computational Instant
RTPA.JK	=	Correctional Term (RTPA accounts for changes in initial planting densities during model reruns.)
INMR.JK	=	Correctional Term (INMR accounts for planting casualties per acre.)
AMR.JK	=	Annual Casualty Rate Between the Prior and Current Computational Instants
MORT1.JK	=	Annual Miscellaneous Casualty Rate Between the Prior and Current Computational Instants

The initial planting density (TPA) is assigned a value of 200 trees per acre for the initial simulation run in a group of simulation reruns. The initial value of HSTPA is assigned a corresponding value of 200. TPA is changed to account for different planting densities on simulation reruns (HSTPA is not changed on reruns) and RTPA is a correctional term that automatically corrects HSTPA to account for a change in TPA. Computations for RTPA are summarized as follows:

```
C    TPA=200
7A   TPA2.K=TPA-200
51A  TPA1.K=CLIP(TPA2.K,0,N.K,1.0)
51R  RTPA.KL=CLIP(0.0,TPA1.K,N.K,2.0)
```

TPA	=	Initial Planting Density in Trees per Acre
TPA2.K	=	Correctional Term Value
TPA1.K	=	CLIP Function
RTPA.KL	=	CLIP Function (The two CLIP functions work together to apply the planting density correctional factor during the third computational instant.)
N.K	=	Years Since Planting at Current Computational Instant (N.K is computed by subprogram 2.)

It is necessary that the harvestable surviving trees per acre (HSTPA) be corrected to account for planting casualties. The correctional term for planting casualties (INRM) is computed as follows:

```
7A   INMP.K=1.0-INSUP
C    INSUP=0.88
12A  INMN.K=(TPA)(INMP.K)
51A  INMN1.K=CLIP(INMN.K,0,N.K,1.0)
51R  INMR.KL=CLIP(0.0,INMN1.K,N.K,2.0)
```

INSUP	=	Planting Survival Rate (This is estimated at 88 percent.)
INMP.K	=	Percentage of Trees That are Planting Casualties
INMN.K	=	Planting Casualties per Acre
INMN1.K	=	CLIP Function
INMR.KL	=	CLIP Function (The two CLIP functions work together to apply the planting casualty correctional factor during the third computational instant.)
N.K	=	Years Since Planting at Current Computational Instant (N.K is computed by subprogram 2.)
TPA	=	Initial Planting Density in Trees per Acre

The annual casualty rate (AMR) is estimated by the following equation:

```
13R  AMR.KL=(HSTPA.K)(BASA3.K)(AMPC)
```

HSTPA.K	=	Harvestable Surviving Trees per Acre
BASA3.K	=	Basal Area Percent of Full Stocking (BASA3 is computed by subprogram 10.)
AMPC	=	Basic Annual Casualty Rate (AMPC is estimated at 1.2 percent.)

The miscellaneous annual casualty rate (MORT1) is used to account for effects on harvestable tree casualties such as very dry periods, insect infestation, and disease infestation. This term is added to give the model flexibility. It is assigned 0 values for this simulation. MORT1 is computed as follows:

```
12A  MORT1.KL=(MORT2.K)(HSTPA.K)
59A  MORT2.K=TABLE(MORT3,N.K,0,40,40)
C    MORT3*=0/0
```

MORT1.KL	=	Annual Miscellaneous Casualties per Acre
MORT2.K	=	Annual Miscellaneous Casualty Percentage
MORT3*	=	Annual Miscellaneous Casualty Percentage for Each Year
HSTPA.K	=	Harvestable Surviving Trees per Acre for Current Computational Instant
N.K	=	Years Since Planting at Current Computational Instant (N.K is computed by subprogram 2.)

Basal area and D.B.H. computations are based on the number of defective and harvestable trees on an acre. Defective trees are estimated to be 20 percent of the casualties. The total number of harvestable and defective trees per acre (XSTAF) is computed by the following equations:

```
14A  XSTAF.K=HSTPA.K+(MORT.K)(0.2)
52L  MORT.K=MORT.J+(DT)(INMR.JK+AMR.JK+MORT1.JK+0.0)
```

XSTAF.K	=	Harvestable Trees and Defective Trees per Acre at Current Computational Instant
HSTPA.K	=	Surviving Harvestable Trees per Acre at Current Computational Instant
MORT.K	=	Cummulative Casualties at Current Computational Instant (MORT includes defectives and fatalities, and defective trees are estimated at 20 percent of the casualties.)
MORT.J	=	Cummulative Casualties at Prior Computational Instant
INMR.JK	=	Correctional Term (INMR accounts for trees per acre that are planting casualties.)
AMR.JK	=	Annual Casualty Rate Between the Prior and Current Computational Instants
MORT1.JK	=	Annual Miscellaneous Casualty Rate Between the Prior and Current Computational Instants

Subprogram 11 computes the unsuppressed basal area (BAXAS) for the next computational instant (year N+1). The number of harvestable and defective trees (XSTPA) at the next computational instant must be estimated. In order to compute XSTPA, it is assumed that the change in defective and harvestable trees is the same between the current and next computational instants as it is between the prior and current computational instants. The computations for estimating XSTPA are summarized as follows:

```
6A    STPA1*1.K=XSTAF.K
37B   STPA1.K=BOXLIN(2,1)
C     STPA1*=1/1
7A    STPA2.K=STAF.K-STPA1*2.K
51A   STPA6.K=CLIP(STPA2.K,0.0,N.K,3.0)
7A    XSTPA.K=XSTAF.K+STPA6.K
```

STPA1*1.K	=	Helps STPA1.K and STPA1*2.K Delay XSTAF.K Values 1 Computational Interval
STPA1.K	=	Helps STPA*1.K and STPA1*2.K Delay XSTAF.K Values 1 Computational Interval
STPA1*2.K	=	Surviving Harvestable and Defective Trees per Acre at Prior Computational Instant
STPA1*	=	Initial Values of STPA1.K
XSTAF.K	=	Surviving Harvestable and Defective Trees per Acre at Current Computational Instant
STPA6.K	=	CLIP Function (CLIP function does not allow feedback of STPA2 values until fourth computational instant to allow model stabilization.)
XSTPA.K	=	Estimated Harvestable and Defective Trees at Next Computational Instant

The harvestable surviving tree percentage (SURP) of initial planting density is computed by the following equation:

```
20A   SURP.K=HSTPA.K/TPA
```

SURP.K	=	Harvestable Surviving Tree Percentage of Initial Planting Density at Current Computational Instant
HSTPA.K	=	Surviving Harvestable Trees per Acre at Current Computational Instant
TPA	=	Initial Planting Density in Trees per Acre

Subprogram 6

Basal area is the square feet of tree cross section at breast height. Basal area per acre is used to estimate when growth suppression occurs. The basal area per acre (BASAS) is computed as follows:

```
13A  BASAT.K=(3.1415927)(DBH.K)(DBH.K)
20A  BASAF.K=BASAT.K/4
44A  BASAS.K=(BASAF.K)(XSTAF.K)/144
```

DBH.K = Tree Diameter at Breast Height at Current Computational Instant (DBH is computed by subprogram 3.)
BASAT.K = Computational Factor for BASAF
BASAF.K = Cross Sectional Area of Individual Trees (BASAF is in square inches.)
XSTAF.K = Surviving Harvestable and Defective Trees per Acre at Current Computational Instant (XSTAF is computed by subprogram 5.)
BASAS.K = Basal Area per Acre (BASAS is in square feet.)

Subprogram 7

When growth suppression is necessary, the D.B.H. growth is suppressed. Basal area is directly related to D.B.H. and tree density. During growth suppression the basal area increases, between the current and next computational instants, are assumed less than the increase between the prior and current computational instants. Subprogram 10 determines a factor (BASA4) that estimates the basal area increase between the current and next computational instants relative to the increase from the prior to the current computational instants. This subprogram estimates the basal area (BAXA3) at the next computational instant. Computations for the BASAS are summarized below:

```
6A   BASA1*1.K=BASAS.K
37B  BASA1.K=BOXLIN(2,1)
C    BASA1*=1/0
7A   BASD2.K=BASAS.K-BASA1*2.K
12A  BAXA2.K=(BASA4.K)(BASD2.K)
7A   BAXA3.K=BASAS.K+BAXA2.K
```

BASA1*1.K = Helps BASA1.K and BASA1*2.K Delay BASAS.K Values 1 Computational Interval
BASA1.K = Helps BASA1*1.K and BASA1*2.K Delay BASAS.K Values 1 Computational Interval
BASA1*2.K = Basal Area per Acre at Prior Computational Instant
BASA1* = Initial Values for BASA1.K

BASAS.K =	Basal Area per Acre for Current Computational Instant (BASAS.K is computed by subprogram 6.)
BASD2.K =	Change in Basal Area Between the Prior and Current Computational Instants
BASA4.K =	Basal Area Suppression Factor (BASA4 is computed by subprogram 10.)
BASA3.K =	Estimated Basal Area at Next Computational Instant

Subprogram 8

This subprogram computes the D.B.H. suppression factor (BASL4). Prior to growth suppression, the tree D.B.H. is equal to the D.B.H. regression equation in subprogram 3. When growth suppression occurs, the results of the regression equation is suppressed by BASL4 in subprogram 3.

Subprogram 11 computes the basal area (BAXAS) that results from an unsuppressed D.B.H. at the next computational instant. Subprogram 7 computes the suppressed basal area (BAXA3) at the next computational instant. The D.B.H. suppression factor (BASL4) is assigned a value to suppress the D.B.H. regression equation results so that the basal area at the next computational instant is equal to the BAXA3 value instead of the BAXAS value. The BASL4 value is delayed 1 computational interval before it is used by subprogram 3.

Subprogram 9 computes the basal area (BASA5) at which growth suppression starts. Subprogram 6 computes the resulting basal area (BASAS) at the current computational instant. Subprogram 10 computes the ratio (BASA3) of the current basal area (BASAS) to the basal area (BASAS) at which suppression starts. When BASA3 is less than 1, BASL4 is equal 1; and when BASA3 exceeds 1, BASL4 is assigned values to provide the suppressed basal area (BAXA3). Computations for BASL4 are summarized as follows:

```
20A  BAXA4.K=BAXA3.K/BAXAS.K
51A  BAXA6.K=CLIP(BAXA4.K,0.000001,BAXA4.K,0.000001)
30A  BASL3.K=(1)SQRT(BAXA6.K)
51A  BASL5.K=CLIP(BASL3.K,1.0,BASA3.K,1.0)
6A   BASL6*1.K=BASL5.K
37B  BASL6.K=BOXLIN(2,1)
C    BASL6*=1/1
6A   BASL4.K=BASL6*2.K
```

BAXA4.K =	Ratio of Suppressed Basal Area to Unsuppressed Basal Area at the Next Computational Instant
BAXA3.K =	Suppressed Basal Area at the Next Computational Instant (BAXA3 is computed by subprogram 7.)
BAXAS.K =	Unsuppressed Basal Area at the Next Computational Instant (BAXAS is computed by subprogram 11.)
BAXA6.K =	CLIP Function (BAXA6.K holds BAXA4.K values positive.)
BASL3.K =	D.B.H. Suppression Value
BASL5.K =	CLIP Function (BASL5.K is assigned the value of BASL3.K when BASA3.K is assigned a value of 1 when BASA3.K is less than 1.)
BASA3.K =	Ratio of Current Basal Area to Basal Area Value at Which Suppression Starts (BASA3 is computed by subprogram 10.)
BASL6*1.K=	Helps BASL6.K and BASL6*2.K Delay BASL5.K Values 1 Computational Interval
BASL6.K =	Helps BASL6*1.K and BASL6*2.K Delay BASL5.K Values 1 Computational Interval
BASL6*2.K=	BASL5.K Value at Prior Computational Instant
BASL6* =	Initial Values of BASL6.K
BASLK.K =	D.B.H. Suppression Factor

<u>Subprogram 9</u>

The regression equations for tree growth characteristics, developed by Bennett, McGee, and Clutter (16), do not adequately account for growth suppression at the higher ages. The age distribution for the sample plots (Table 6) indicate that the regression equations are based on data of which 95 percent is from plots less than 20.5 years old. Tree growth suppression, at planting densities considered, normally occurs at ages greater than 20.5 years.

The only usable data on growth suppression is found in a technical paper on volume growth in natural loblolly pine stands by Nelson, Lotti, Brender, and Trousdell (17). This work identifies the square feet of basal area per acre for full stocking relative to D.B.H. and the basal area at maximum growth rates relative to site index.

The full stocking basal areas per acre relative to D.B.H. is presented in Table 7. The following equation for full stocking relative to D.B.H. was developed to represent the data in Table 7.

$$\text{Full Stocking} = 133 + 3(\text{D.B.H.}) - (12/(\text{D.B.H.} + (4/\text{D.B.H.})))^{3.73} - (\text{D.B.H.}/11.)^{4.5}$$

The results of this equation are also presented in Table 7 for a comparison of values.

The full stocking equation is programmed as follows:

```
12A   BASS1.K=(3.0)(DBH.K)
27A   BASS2.K=(4.0/DBH.K)+DBH.K
20A   BASS3.K=12/BASS2.K
29A   BASS4.K=(3.73)LOGN(BASS3.K)
28A   BASS5.K(1.0)EXP(BASS4.K)
20A   BASS6.K=DBH.K/11
29A   BASS7.K=(4.5)LOGN(BASS6.K)
28A   BASS8.K=(1)EXP(BASS7.K)
9A    BASS9.K=133+BASS1.K-BASS5.K-BASS8.K
```

DBH.K	=	Diameter at Breast Height at Current Computational Instant (DBH.K is computed by subprogram 3.)
BASS1.K	=	Second Term of Full Stocking Equation
BASS2.K	=	Computational Factor for BASS3.K
BASS3.K	=	Computational Factor for BASS4.K
BASS4.K	=	Computational Factor for BASS5.K
BASS5.K	=	Third Term of Full Stocking Equation
BASS6.K	=	Computational Factor for BASS7.K
BASS7.K	=	Computational Factor for BASS8.K
BASS8.K	=	Fourth Term of Full Stocking Equation
BASS9.K	=	Full Stocking Basal Area Relative to D.B.H.

The above data and equations identify full stocking relative to

Table 7. Basal Area at Full Stocking versus Diameter at Breast Height

Diameter at Breast Height in Inches	Basal Area (in Square Feet) per Acre by Reference (17)	Basal Area (in Square Feet) per Acre by Full Stocking Equation
4	119	119
6	140	141.9
8	153	153.13
10	161	160.65
12	167	166.63
14	172	171.50
16	175	175.28

Table 8. Growth Suppression Relative to Site Index and Full Stocking

Site Index (50 year)	Site Index (25 year)	Basal Area (Square Feet per Acre) at which Growth Suppression is Intiated (10 Inch D.B.H.)		Full Stocking Basal Area (Square Feet per Acre) at 10 Inch D.B.H.	Percent of Full Stocking at Which Suppression Initiates
		Natural Stand	Plantation Stand (30 Percent Increase Over Natural)		
100	78	145	188	161	117
90	70	130	169	161	105
80	62.5	118	153	161	95
70	54.5	105	137	161	85
60	46.5	90	117	161	73

D.B.H. It is now necessary to determine at what percentage of full stocking growth suppression starts. Nelson, Lotti, Brender, and Trousdell (17) presented annual volume growth for various site indices and basal areas per acre. These data are used to identify the basal area per acre related to maximum volume growth, at 30 years, for various site indices. The basal area at maximum volume growth is presented in Table 8 as a function of site index.

The above data are based on 50 year site indices. The growth model is based on 25 year site indices. The two site indices are correlated by the height regression equation in subprogram 4. Equivalent 25 year and 50 year site indices are presented in Table 8.

Growth suppression is assumed to be the major cause of the reduced growth rate as the basal area becomes greater than the values (related to maximum growth rates) in Table 8. Therefore, growth suppression is assumed to start at basal areas that produce the maximum growth rate.

In order to determine at what percent of full stocking suppression occurs, it is necessary to identify the D.B.H. values related to optimal growth rates because the full stocking basal areas are related to D.B.H. The maximum growth rate data for 90 foot site index (130 square feet of basal area per acre at 30 years) are chosen as base data to relate the basal area at maximum growth rate and full stocking. Based on interpolated data from Table 22 of the Forestry Handbook by Forbes (18), it is estimated that 10 inch D.B.H. trees would be grown on a 90 foot site with 130 square feet of basal area per acre at 30 years. According to Table 7, the full stocking basal area for 10 inch D.B.H. trees is 161 square feet of basal area per acre.

The data presented by Nelson, Lotti, Brender, Trousdell (17), and Forbes (18) are based on natural stands. Millar (14) reports that most of the important softwood and hardwood species in the United States are intolerant of shade which means they grow best in stands of approximately the same age. Dyck (1) reports that properly planned and managed forests can produce productivity increases of over 30 percent. Millar's and Dyck's statements are interpreted to mean that geometrically oriented, even-aged forest stands have productivity approximately 30 percent greater than related natural stands. In view of this, it is assumed that the basal area related to optimal growths in forest plantations is approximately 30 percent higher than related basal areas in natural stands. Therefore, the basal areas related to optimal annual growth for natural stands is increased by 30 percent to account for improved growing conditions related to plantation forest stands. The resulting increased basal areas are presented in Table 8.

The increased basal area for plantation forest stands, at 90 foot site index, is compared to the full stocking basal area for the 10 inch D.B.H. to determine the percent of full stocking at which suppression is initiated. It is assumed that the maximum growth basal areas at other site indices are similarly related to full stocking at 10 inch D.B.H. values. The percent of full stocking for 10 inch D.B.H. at which suppression is initiated is computed for other site indices and presented in Table 8.

The percentages of full stocking, in Table 8, are plotted relative to 25 year site indices. This data closely fits a straight line between 65 percent for site index 40 and 120 percent for site index 80. It is assumed that these percentages can be applied to full stocking at other D.B.H.s.

The above data are used to determine the basal area (BASA5) at which growth suppression starts relative to site index and D.B.H. Computation of BASA5 is summarized as follows:

```
59A  BAS10.K=TABLE(BAS11,SITEI,40,80,40)
C    BAS11*=0.65/1.20
12A  BASA5.K=(BASS9.K)(BAS10.K)
```

BAS10.K	=	Percent of Full Stocking at Which Growth Suppression Is Initiated
BAS11*	=	Table Values for BAS10.K
SITEI	=	Site Index of Land (SITEI is assigned values by subprogram 1.)
BASS9.K	=	Basal Area Relative to D.B.H. at Full Stocking (BASS9.K is in square feet per acre.)
BASA5.K	=	Basal Area at Which Growth Suppression Is Initiated (BASA5 is in square feet per acre.)

Subprogram 10

This subprogram determines the degree that growth will be suppressed between the current and next computational instants as compared to the growth between the prior and current computational instants.

Growth suppression is assumed to result from trees competing for growing space and nutrients. As the trees grow larger, their requirements increase while the growing space and nutrients remain constant. In view of this, it is assumed that suppression begins at a zero value and progressively increases until growth ceases.

Projections of basal area versus growth data (17) indicates that basal area growth is completely suppressed at approximately 150 percent of the basal area at which suppression is initiated.

Therefore, it is expected that the slope of the basal area versus age curve will progressively decrease from the slope of the curve where suppression is initiated. As age further increases, the curve should asymptotically approach zero slope at approximately 150 percent of the basal area value at which growth suppression is initiated.

Subprogram 7 computes the basal area at the next computational instant when growth suppression occurs. The suppressed basal area (BASA3) is determined by requiring the basal area increase between current and next computational instants to be a percentage (BASA4) of the basal area increase between the prior and current computational instants. The basal area suppression factor (BASA4) is assigned values so that growth is suppressed as described above (progressively decreasing slope when suppression is initiated and asymptotically approaching zero slope at approximately 150 percent of the value of basal area (BASA5) at suppression initiation).

Experimentation was conducted to determine a means of computing values of BASA4 (basal area suppression factor) that would produce the desired growth suppression. The desired curve results if BASA4 is assigned values linearly from 1.0 to 0.5 as values of BASA3 (raised to the 4.2 power) increase from 1 to 7. BASA3 is the ratio of BASAS to BASA5. BASAS is the basal area at the current computational instant and it is computed by subprogram 7. BASA5 is the basal area at which suppression is initiated and it is computed by subprogram 9.

The computation of BASA4 is summarized as follows:

```
20A  BASA3.K=BASAS.K/BASA5.K
51A  BAXA9.K=CLIP(BASA3.K,1.0,BASA3.K,1.0)
29A  BAXA7.K=(4.20)LOGN(BAXA9.K)
28A  BAXA8.K=(1)EXP(BAXA7.K)
```

```
59A   BASA4.K=TABHL(BASTA,BAXA8.K,1.0,7.00,6.00)
C     BASTA*=1.0/.5
```

BASA3.K	=	Ratio of Basal Area at Current Computational Instant to Basal Area at Which Suppression Is Initiated
BASAS.K	=	Basal Area at Current Computational Instant (BASAS.K is computed by subprogram 6.)
BASA5.K	=	Basal Area at Which Suppression Is Initiated (BASA5.K is computed by subprogram 9.)
BAXA9.K	=	CLIP Function (BAXA9.K is equal 1 when BASA3.K is less than 1 or BAXA9.K is equal BASA3.K when BASA3.K is equal 1 or more.)
BAXA7.K	=	Computational Factor for BAXA8.K
BAXA8.K	=	Exponential Function of BASA3
BASTA*	=	Suppression Factor Values as a Linear Function of BAXA8.K
BASA4.K	=	Basal Area Suppression Factor

Subprogram 11

When suppression occurs, subprogram 8 computes the D.B.H suppression factors (BASL4). The D.B.H. suppression factor (BASL4) suppresses D.B.H. values computed by the D.B.H. regression equation in subprogram 3. It is necessary that the unsuppressed D.B.H. be suppressed so that the basal area (BASAS) at the current computational instant is equal to the suppressed basal area (BASAS) computed at the prior computational instant. BASAS is computed by subprogram 6 and BASA3 is computed by subprogram 7.

The value of BASL4 for the current computational instant is computed at the prior computational instant. Therefore, subprogram 8 requires the value of the basal area resulting from the unsuppressed D.B.H. at the next computational instant in order to determine the value of BASL4 required for the next computational instant.

This subprogram computes the unsuppressed basal area (BAXAS) at the next computational instant. The unsuppressed D.B.H., at the next computational instant (DBXT), is computed by the same D.B.H. regression equation used in subprogram 3. The unsuppressed basal area, at the next computational instant (BAXAS), is computed as BASAS in subprogram 6.

The computations for BAXAS are summarized as follows:

```
12A   DBXA1.K=(XAGE.K)(SITEI)
12A   DBXA.K=(0.000219)(DBXA1.K)
29A   DBXB1.K=(F)LOGN(XSTPA.K)
12A   DBXB.K=(0.234544)(DBXB1.K)
9A    DBXL.K=(0.650712+DBXA.K-DBXB.K+DBHC.K)
12A   DBXL1.K=(2.3025851)(DBXL.K)
28A   DBXT.K=(X)EXP(DBXL1.K)
13A   BAXAT.K=(3.1415927)(DBXT.K)(DBXT.K)
20A   BAXA5.K=BAXAT.K/4
44A   BAXAS.K=(BAXA5.K)(XSTPA.K)/144
```

XAGE.K	=	Tree Age at Next Computational Instant (XAGE.K is computed by subprogram 2.)
SITEI	=	Site Index of the Land (SITEI value is assigned by subprogram 1.)
DBXA1.K	=	Computational Factor for DBXA.K
DBXA.K	=	Second Term of D.B.H. Regression Equation
F	=	1 (F is a computational constant established by subprogram 1.)
XSTPA.K	=	Estimated Harvestable and Defective Trees at Next Computational Instant (XSTPA.K is computed by subprogram 5.)
DBXB1.K	=	Computational Factor for DBXB.K
DBXB.K	=	Third Term of D.B.H. Regression Equation
DBXL.K	=	Common Logarithm of D.B.H. at Next Computational Instant
DBXL1.K	=	Natural Logarithm of D.B.H. at Next Computational Instant
X	=	1 (X is a computational constant established by subprogram 1.)
DBXT.K	=	Unsuppressed D.B.H. at Next Computational Instant
BAXAT.K	=	Computational Factor for BAXA5.K
BAXA5.K	=	Cross Sectional Area of Individual Tree at Next Computational Instant (BAXA5.K is in square inches.)
BAXAS.K	=	Basal Area per Acre at Next Computational Instant (BAXAS is in square feet.)

<u>Subprogram 12</u>

The tree volume is a function of tree height and tree D.B.H. The regression equation (16) for tree volume inside the bark at a 3 inch diameter top is as follows:

$$V3I2 = 0.002135(HGH)(DBH)^2-0.693239$$

This equation is programmed as follows:

```
13A  VOLF.K=(DBH.K)(DBH.K)(HGH.K)
12A  V3I1.K=(0.002135)(VOLF.K)
7A   V3I2.K=V3I1.K-0.693239
```

DBH.K	=	Tree D.B.H. (DBH.K is computed by subprogram 3.)
HGH.K	=	Tree Height (HGH.K is computed by subprogram 4.)
VOLF.K	=	Computational Factor for V3I1.K
V3I1.K	=	First Term of Tree Volume Regression Equation
V3I2.K	=	Tree Volume Inside Bark Below a 3 Inch Diameter Top at Current Computational Instant (V3I2.K is in cubic feet.)

Based on wood volume data compiled by Taras (19), it is estimated that there are 72 cubic feet of wood per cord. Based on this, the estimated number of trees per cord (V3ITC) is computed as follows:

```
20A  V3ITC.K=72/V3I2.K
```

V3I2.K	=	Tree Volume Inside Bark Below a 3 Inch Diameter Top at Current Computational Instant
V3ITC.K	=	Trees per Cord at Current Computational Instant

The tree weight (V3IWT) is estimated as follows:

```
44A  V3IWT.K=(V3I2.K)(CDWT)/72
```

V3I2.K	=	Tree Volume Inside Bark Below a 3 Inch Diameter Top at Current Computational Instant
CDWT	=	Cord Weight (CDWT value is assigned by subprogram 13 of the economic model.)
V3IWT.K	=	Merchantable Tree Weight at Current Computational Instant

The harvester can only harvest 50 feet of a tree in a single processing sequence. Trees are estimated to have 15 feet of top above the 3 inch top diameter; therefore, 65 foot high trees have a 50 foot merchantable stem.

Trees are not expected to greatly exceed 65 feet in height; therefore, the harvester is not recycled to process wood remaining in tops of trees over 65 feet in height. Subprogram 13 of the economic model estimates the percentage (V3I70) of the merchantable stem that is harvested when trees are over 65 feet high. The harvestable yield (V3I60) is computed as follows:

```
12A  V3I4.K=(HSTPA.K)(V3I2.K)
20A  V3I10.K=V3I4.K/72
51A  V3I5.K=CLIP(V3I10.K,1,V3I10.K,1)
12A  V3I60.K=(V3I5.K)(V3I70.K)
```

V3I2.K	=	Tree Volume Inside Bark Below a 3 Inch Diameter Top at Current Computational Instant
HSTPA.K	=	Harvestable Surviving Trees at Current Computational Instant (HSTPA.K is computed by subprogram 5.)
V3I4.K	=	Yield per Acre at Current Computational Instant (V3I4.K is in cubic feet.)
V3I10.K	=	Yield per Acre at Current Computational Instant (V3I10.K is in cords.)
V3I5.K	=	CLIP Function (V3I5.K equals 1 when V3I10.K is less than 1 or V3I5.K equals V3I10.K when V3I10.K equals 1 or more.)
V3I70.K	=	Harvestable Volume (V3I70.K accounts for volume that cannot be harvested in a single processing sequence on trees over 65 feet high. V3I70.K is computed by subprogram 13 of the economic model.)
V3I60.K	=	Harvestable Yield per Acre at Current Computational Instant (V3I60.K is in cords.)

The harvestable yield per acre per year average (V3I61) is computed as follows:

```
20A  V3I61.K=V3I60.K/AGE.K
```

AGE.K	=	Age of Trees at Current Computational Instant (AGE.K is computed by subprogram 2.)
V3I60.K	=	Harvestable Yield per Acre at Current Computational Instant
V3I61.K	=	Harvestable Cords per Acre per Year Average at Current Computational Instant

CHAPTER VIII

FOREST GROWTH MODEL EXPERIMENTATION AND RESULTS

The forest growth model is developed to determine tree and forest characteristics relative to forest planning and management alternatives by model experimentation. The tree characteristics considered in the model experimentation are tree height, D.B.H., weight, and volume; whereas the forest characteristics considered are yield, survival, and tree distribution. Forest planning alternatives considered in the model experimentation are initial planting density and the land site index on which the trees are planted; whereas the forest management alternative considered is the age at which the forest is harvested.

The forest growth model is run at site indices 40, 50, 60, 70, and 80. For each site index, initial planting densities are varied from 200 to 1,000 trees per acre in increments of 100 trees per acre. Time is increased from planting time to 40 years in 1 year increments. The computed forest and tree characteristics are supplied directly to the economic model that is run simultaneously with this model.

The resulting tree and forest characteristics are printed and plotted at each subsequent year after planting. The resulting data are plotted for 10 to 40 years and presented in figures as follows:

(1) Tree Height versus Age for Trees on Land with Site Indices 40 to 80 is Figure 4.

(2) Survival versus Age for Initial Planting Densities of 200 to

1,000 Trees per Acre on Land with: Site Index 40 is Figure 15, Site Index 50 is Figure 16, Site Index 60 is Figure 5, Site Index 70 is Figure 17, and Site Index 80 is Figure 18.

(3) Diameter at Breast Height versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with: Site Index 40 is Figure 19, Site Index 50 is Figure 20, Site Index 60 is Figure 6, Site Index 70 is Figure 21, and Site Index 80 is Figure 22.

(4) Basal Area versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with: Site Index 40 is Figure 23, Site Index 50 is Figure 24, Site Index 60 is Figure 7, Site Index 70 is Figure 25, and Site Index 80 is Figure 26.

(5) Harvestable Yield versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with: Site Index 40 is Figure 27, Site Index 50 is Figure 28, Site Index 60 is Figure 8, Site Index 70 is Figure 29, and Site Index 80 is Figure 30.

(6) Merchantable Stem Weight versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with: Site Index 40 is Figure 31, Site Index 50 is Figure 32, Site Index 60 is Figure 9, Site Index 70 is Figure 33, and Site Index 80 is Figure 34.

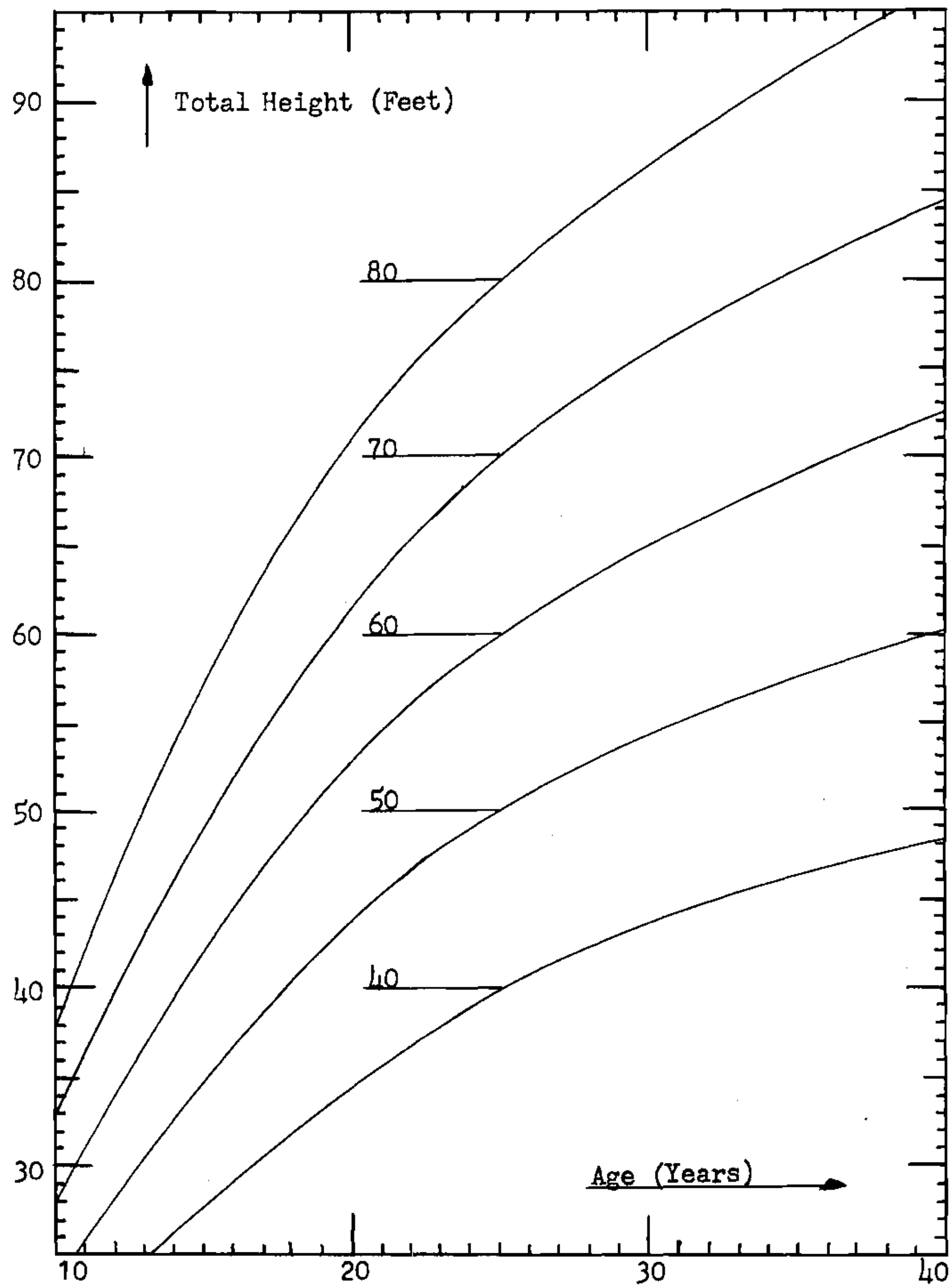


Figure 4. Total Height versus Age for Trees on Land with Site Indices 40 to 80

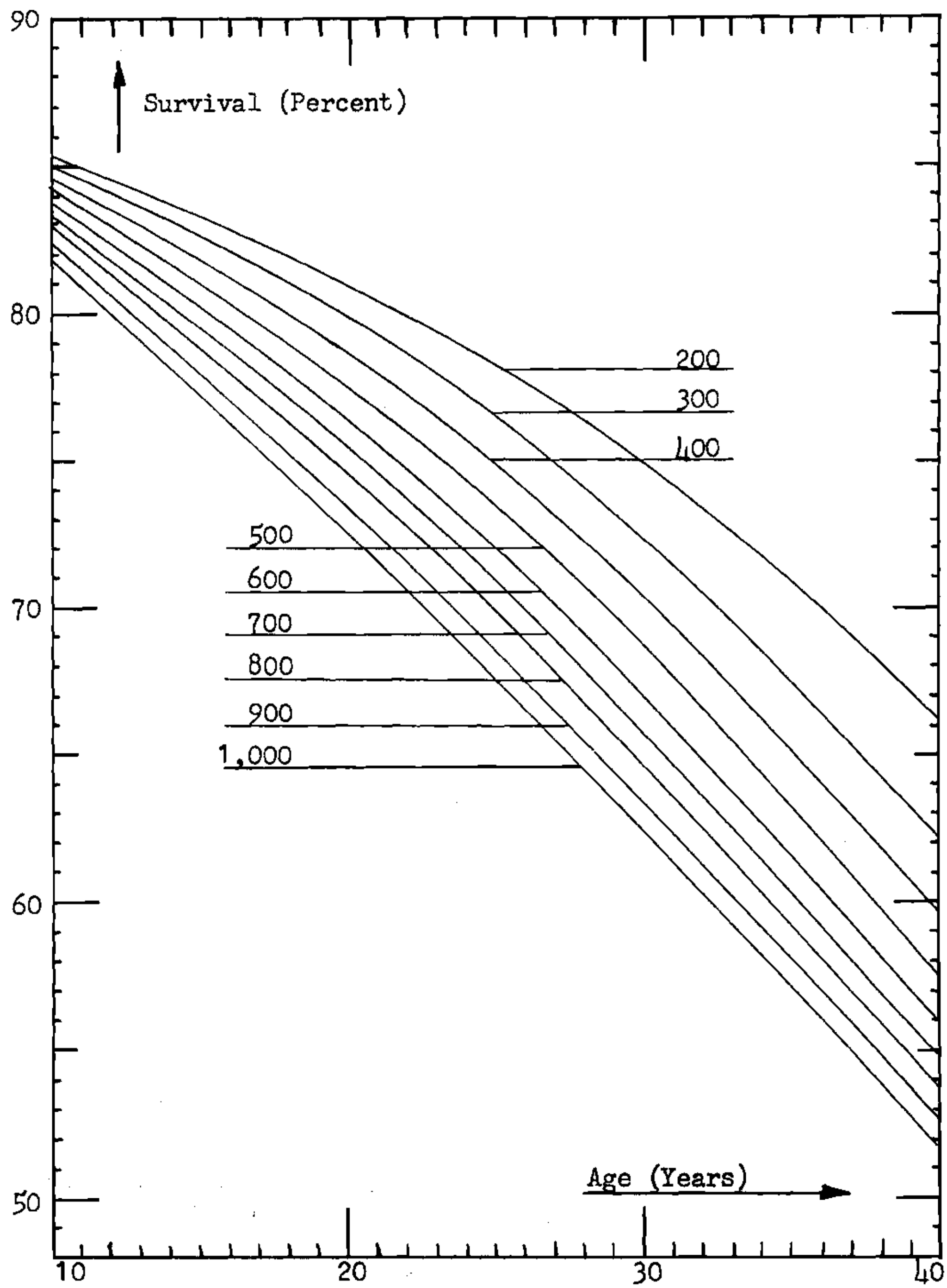


Figure 5. Survival versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 60

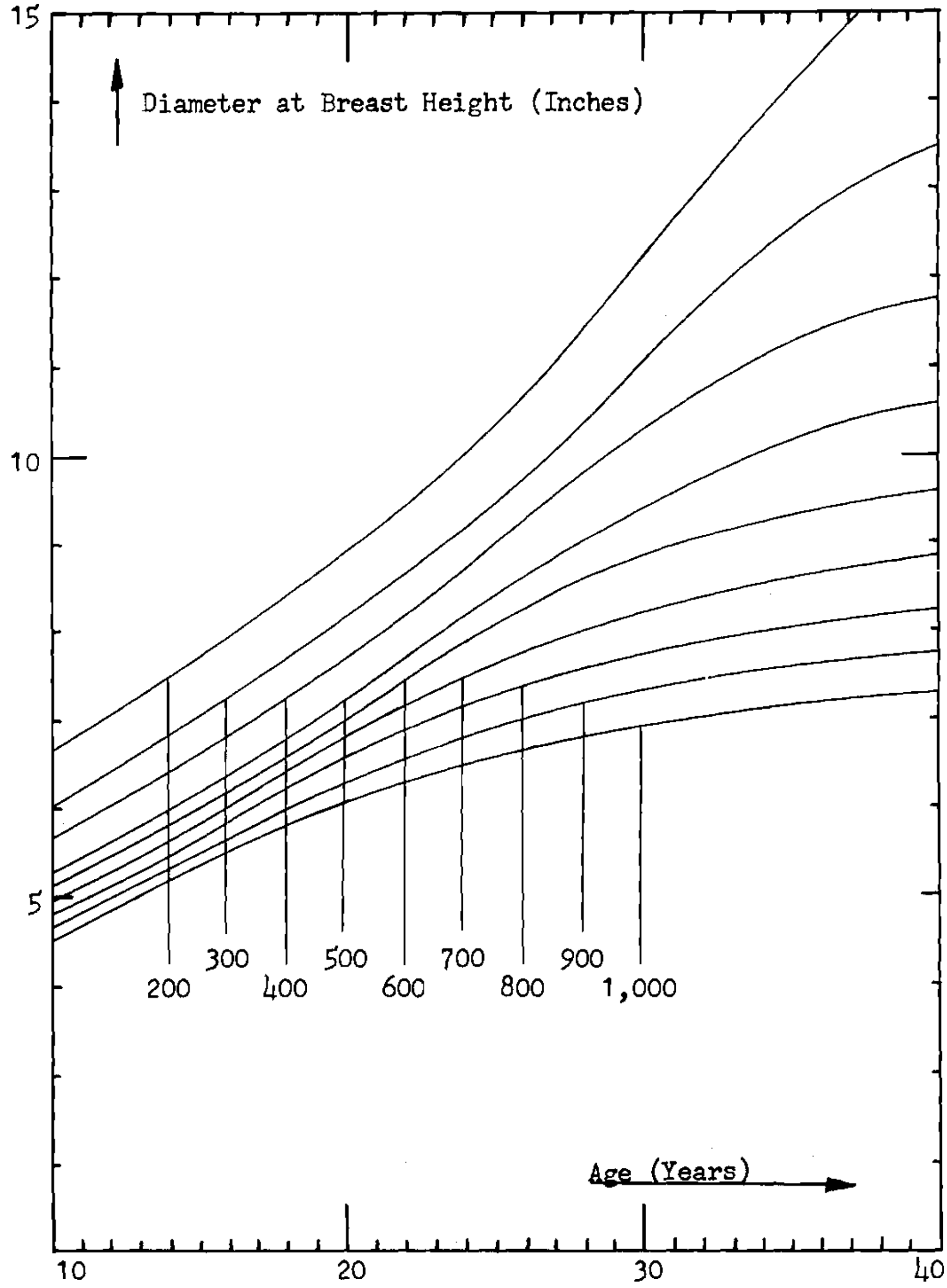


Figure 6. Diameter at Breast Height versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 60

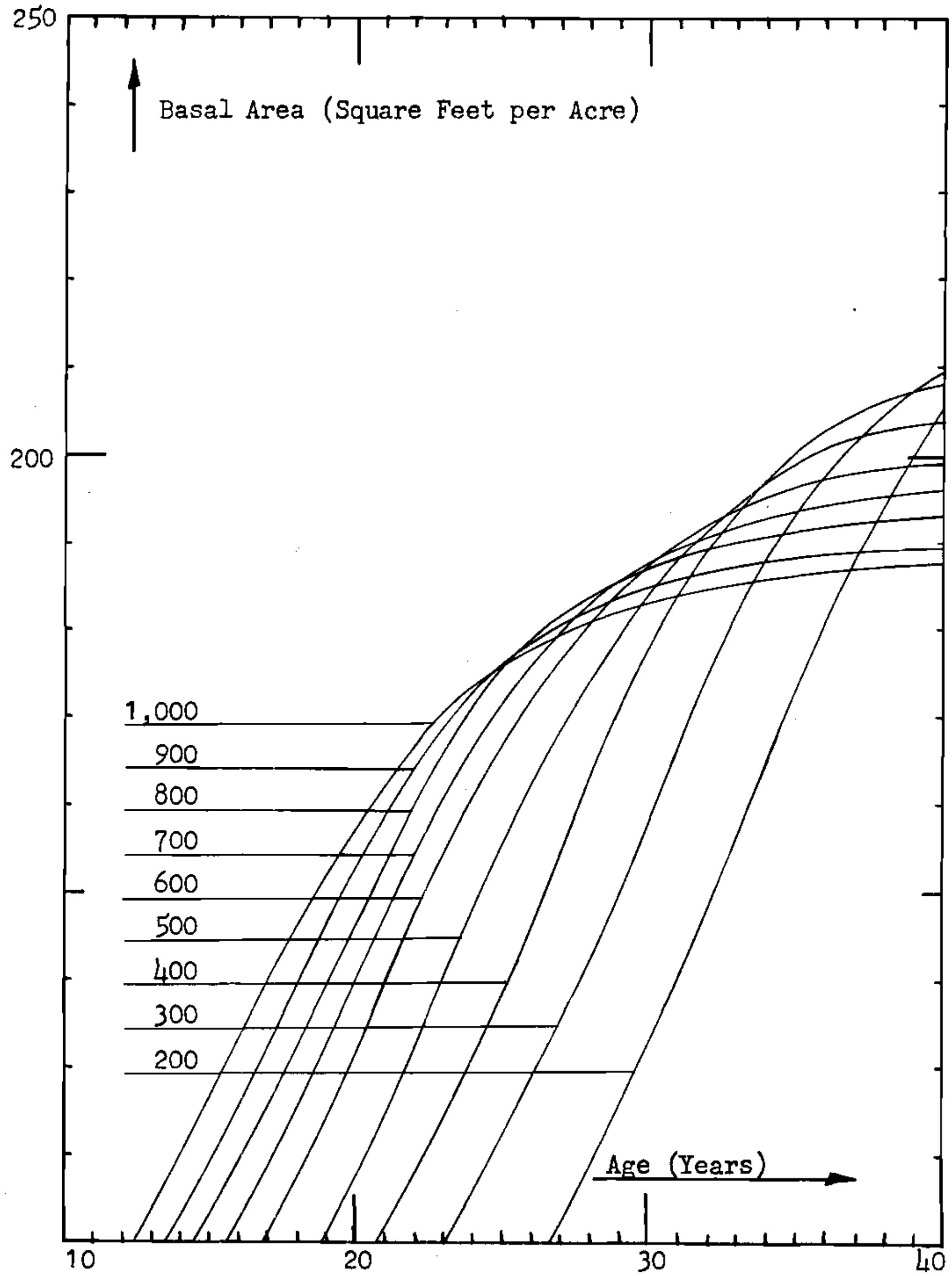


Figure 7. Basal Area versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 60

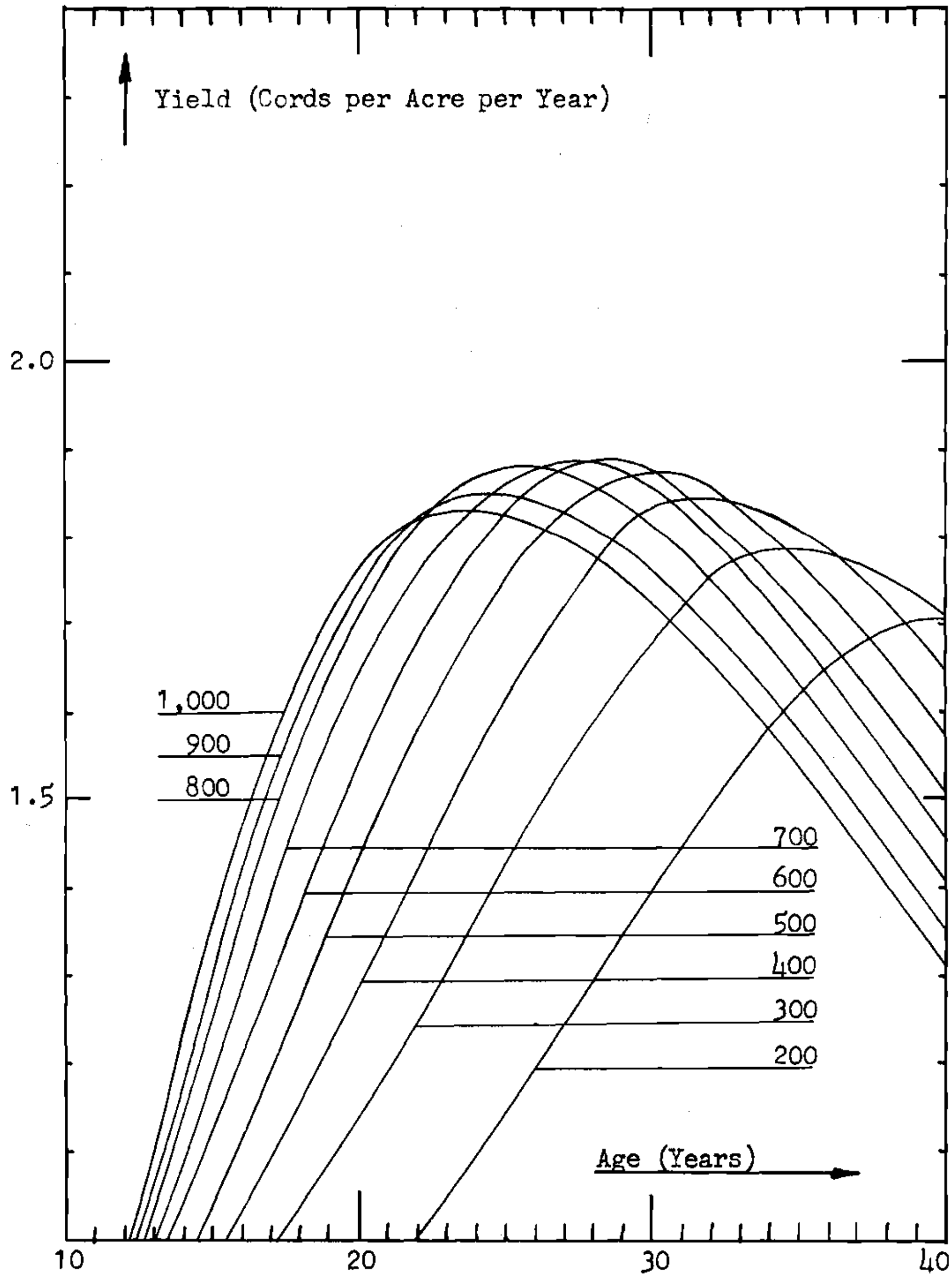


Figure 8. Harvestable Yield versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 60

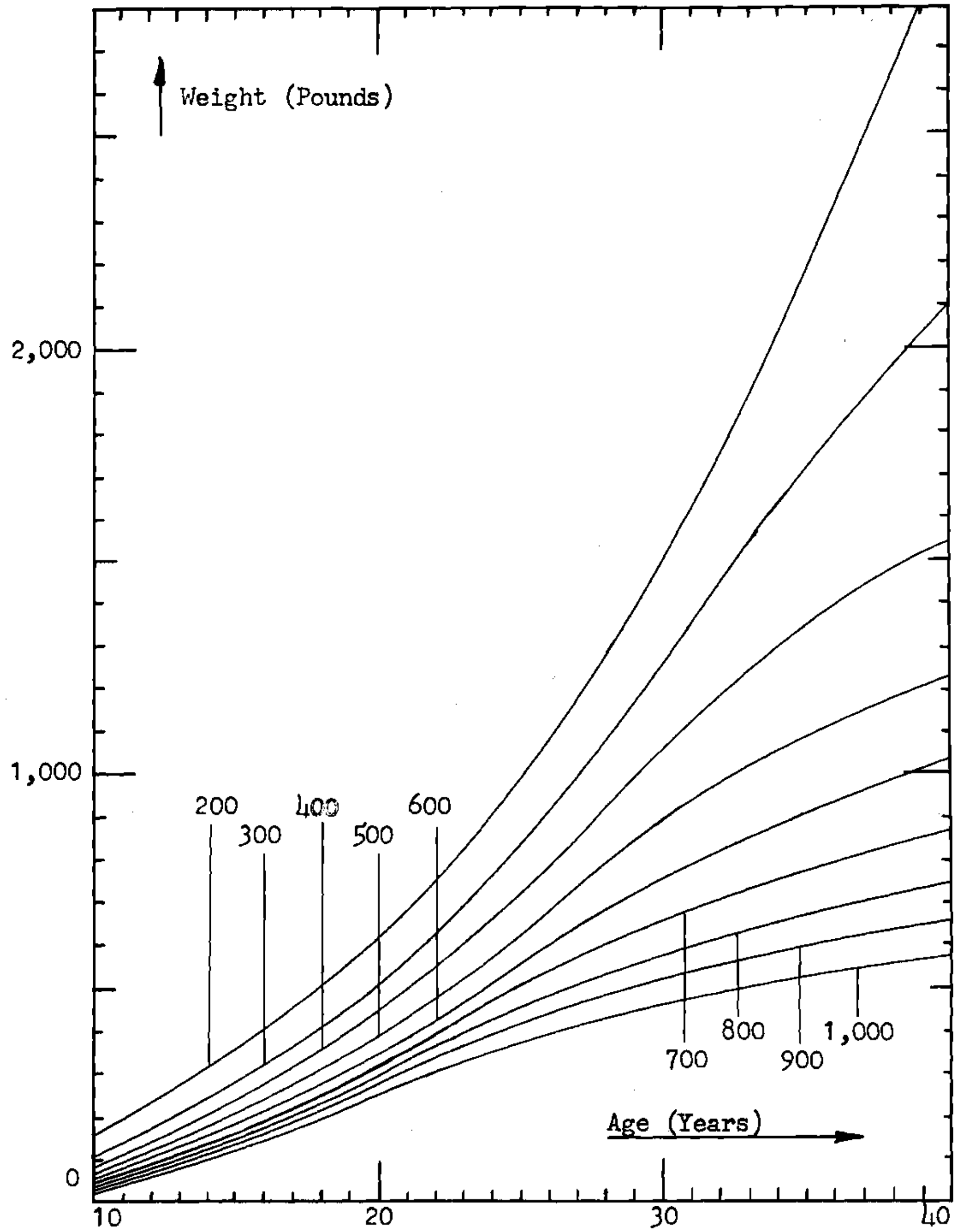


Figure 9. Merchantable Stem Weight versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 60

CHAPTER IX

ECONOMIC MODEL

Discussion of the Economic Model

It is desirable to economically evaluate the proposed harvester design in conjunction with forest planning and management alternatives. An economic evaluation is desirable because of management objectives of the independent landowner and the paper company. The private landowner normally desires to plan, manage, and harvest the forest so as to obtain the maximum return on investments and expenses; whereas the goal of the paper company is to plan, manage, and harvest the forest so as to reduce wood cost to a minimum.

An economic simulation model is developed to evaluate the harvester's design in conjunction with forest planning and management alternatives relative to economically oriented management objectives.

The forest is a long-term investment and there are many factors that affect the rate of return and wood cost. The economic model is designed to determine initial investments, initial expenses, follow-on expenses, and harvesting expenses related to the machine design and forest planning and management alternatives. All costs are based on their value at planting time and economics factors such as inflation. The forest asset value at harvesting time, is also determined by the economic model.

The initial investment is the land value at planting time. The land value is assumed to be a linear function of the site index.

The initial expenses are costs related to site clearing, site preparation, and planting. Site clearing is only required for the initial plantation planting. The site preparation is the clearing of small underbrush and soil preparation. The planting cost considered is the tree seedling and planting costs.

The follow-on expenses consist of annual taxes and management costs. These costs are a function of inflation and their related costs at planting time.

The harvesting cost is based on harvester performance, harvester operating cost at planting time, and inflation. The harvester's performance is determined relative to tree and forest characteristics based on the results of the harvester simulation model and the forest growth model. The harvester operating cost computations are contained in Appendix II. In the case of the private landowner, the economic model is designed with an allowance for harvesting cost. If the harvesting cost is different from this allowance, the stumpage price is adjusted to compensate for the difference. In the case of the paper company, the harvesting cost, minus the harvesting cost allowance, is added to the cost of the wood.

The investment value at harvesting time is a function of inflation, stumpage price at planting time, forest yield, harvesting cost, and land value.

The landowner's rate of return and the paper company's wood cost are determined relative to the harvester design and forest planning and management alternatives. The results of the economic model are used to identify forest planning and management alternatives related to maximum rate of return and minimum wood cost. The results of the forest growth model are utilized to determine the tree and forest characteristics related to the maximum rate of return and minimum wood cost. The proposed harvester design needs to be refined in accordance with the tree and forest characteristics related to the optimal forest planning and management alternatives.

The landowner's rate of return is computed from the ratio of the initial value at planting time of all investments and expenses to land value and harvested wood value at harvesting time. The above rate of return data is computed for planning and management alternatives when site clearance is required as well as when site clearance is not required. The landowner's rate of return is computed before income taxes are deducted.

The paper company's wood cost is computed as the summation of all forest investments, forest expenses, and harvesting expenses (minus harvesting cost allowance). The wood cost related to planning and management alternatives is computed for cases where the paper company diverts profits (after taxes) from industrial investments into forest investments. These alternatives are considered for site clearing cost requirements as well as no site clearing cost requirements. The paper company's wood cost is also computed relative to planning and management alternatives when the paper company borrows funds for forest investments as they are required. These alternatives are considered only when site clearance is required.

Development of the Economic Model

The economic model is programmed in DYNAMO computer language (12).

This language is used because of its adaptability for dynamic feedback systems in business, economics, or engineering and its ability to translate mathematical models into tabulated and plotted results. The forest growth model and the economic model are combined into a single computer model and they are run simultaneously. It is desirable to combine the two models due to common time basis and extensive data flow from the forest growth model to the economic model.

The forest growth model is identified as Section I of the combined model, whereas the economic model is identified as Section II. The forest growth model is made up of subprograms 1 through 12 and the economic model is made up of subprograms 13 through 23. The combined models and sample printout are contained in Appendix III.

The purpose of each of the 11 subprograms of the economic model is as follows:

(1) Subprogram 13 computes the harvesting cost per cord at harvesting time.

(2) Subprogram 14 computes the value, at planting time, of all expenses related to planting and growing the forest.

(3) Subprogram 15 computes the land value at 1 year increments after planting.

(4) Subprogram 16 computes the stumpage prices at 1 year increments after planting.

(5) Subprogram 17 computes the annual taxes at 1 year increments after planting.

(6) Subprogram 18 computes the annual management costs at 1 year increments after planting.

(7) Subprogram 19 computes the harvester's hourly operating costs at 1 year increments after planting.

(8) Subprogram 20 computes the harvesting cost allowance at 1 year increments after planting.

(9) Subprogram 21 computes discount factors for follow-on expenses which are invested until required.

(10) Subprogram 22 computes the rate of return for the landowner at 1 year increments after planting.

(11) Subprogram 23 computes the wood growing costs, adjusted for harvesting costs, for the paper company at 1 year increments after planting.

Development of each of the economic model subprograms is discussed in detail.

Subprogram 13

The harvesting cost per cord is a function of operating cost and the production rate. The operating cost is a function of the operating cost at planting time and economic factors such as inflation, and the production rate is a function of the harvester design and the characteristics of the trees and forest.

The harvester simulation model is used to determine the processing cycle time per tree relative to initial planting density, survival, and tree size. The harvester simulation model is used first to determine the processing cycle time for the 5 inch D.B.H. trees as a function of initial planting density and survival percentages. These data are recorded in Table 2. The harvester simulation model is then used to determine the processing time per tree at 700 trees per acre initial planting density as a function of D.B.H. These data are used to determine the difference in the processing time for the 5 inch D.B.H. trees relative to trees with other D.B.H.s. The resulting data are used to determine correctional values to adjust the 5 inch D.B.H. cycle time for other D.B.H.s. The resulting correctional values for 4 surviving ranges is presented in Table 3. It was determined that these correctional values for other D.B.H.s resulted in negligible errors when uniformally applied for initial planting densities other than 700 trees per acre.

The forest growth model, which runs simultaneously with the economic model, determines tree size and survival as a function of initial planting density, site index, and age. The economic model uses these data in conjunction with the data from the harvester model (as recorded in Tables 2 and 3) to determine the harvester processing time per tree relative to tree and forest characteristics as determined by forest planning and management.

The data in Table 2 are made available to the economic model by TABHL functions (CCF22 through CCF30) for each initial planting density (TPA). Each of the TABHL functions is a function of survival (SURP). The TABHL functions (CCF22 through CCF30) are multiplied by related SWITCH functions (CCF12 through CCF22) to compute processing time terms (CCF42 through CCF50) for trees with 5 inch D.B.H. The SWITCH functions are equal to 1 or 0 relative to values of the SWITCH function control factors (CCF02 through CCF10). If the SWITCH functions are equal to 1, their related SWITCH function control factors are equal to 0 or if the SWITCH functions are equal to 0, their related SWITCH function control factors are not equal to 0. The SWITCH function control factors are equal to 0 only for specific initial planting densities (TPA). Therefore, all the processing time per tree terms (CCF42 through CCF50) for 5 inch D.B.H.s are equal to 0 except the one related to the initial planting density (TPA) being considered for this particular simulation run. The processing time term, related to the specified initial planting density (TPA), is equal to the related TABHL function (CCF22 through CCF30). The harvester processing time per tree (CCF53), for 5 inch D.B.H. trees relative to initial planting densities (TPA) and survival, is equal to the sum of the processing time terms (CCF42 through CCF50) of which all but the one related to the specified initial planting density (TPA) are equal to 0.

The harvester processing time per 5 inch D.B.H. trees is then corrected by the processing time correctional term (CCF78) for trees with D.B.H.s other than 5 inches. The processing time per tree correctional term (CCF78) is computed from correctional values recorded in Table 3. The correctional values in Table 3 are made available to the economic model by 4 TABLE functions (CCF61, CCF66, CCF71, and CCF75) for 4 ranges of survival. Each of these TABHL functions is a function of D.B.H. Each of the TABHL functions are multiplied by related CLIP functions (CCF60, CCF64, CCF65, CCF69, CCF70, and CCF74). These CLIP functions are equal to 1 or 0. The logic of the CLIP functions is so that the TABHL function, related to the survival being considered by the economic model, is multiplied by 1 and the other 3 TABHL functions are multiplied by 0. Survival/ D.B.H. correctional values (CCF63, CCF68, CCF73, and CCF77) are the resulting products of the 4 TABHL functions and their related CLIP functions. The processing time per tree correctional term (CCF78) is the sum of the survival/D.B.H. correctional values (CCF63, CCF68, CCF73, and CCF77). The harvester processing time per tree (CCF79) is equal to the sum of the processing time per tree (CCF53) for 5 inch D.B.H. trees and the processing time per tree correctional term (CCF78).

The above computations for initial planting density (TPA) of 500 trees per acre and 75 percent survival are summarized below. Equations and computations for other planting densities and survival are similar.

```
7A    CCF05.K=+TPA-500
49A   CCF15.K=SWITCH(1.0,0.0,CCF05.K)
58A   CCF25.K=TABHL(CCF35,SURP.K,0.5,1.0,0.05)
C     CCF35*=21.7/20.5/19.4/18.523/17.750/17.088/16.503/
             15.9/15.4/14.9/14.5
12A   CCF45.K=(CCF15.K)(CCF25.K)
8A    CCF51.K=+CCF42.K+CCF43.K+CCF44.K
10A   CCF52.K=+CCF45.K+CCF46.K+CCF47.K+CCF48.K+CCF49.K
             +CCF50.K
7A    CCF53.K=+CCF51.K+CCF52.K
51A   CCF69.K=CLIP(+1.0,0.0,SURP.K,0.725)
51A   CCF70.K=CLIP(-1.0,0.0,SURP.K,0.775)
58A   CCF71.K=TABHL(CCF72,DBH.K,4.0,12.0,1.0)
C     CCF72*=-0.333/+0.000/+0.333/+0.775/+1.115/+1.453/
             +2.313/+3.173/+4.033
18A   CCF73.K=(CCF71.K)(CCF69.K+CCF70.K)
9A    CCF78.K=+CCF63.K+CCF68.K+CCF73.K+CCF77.K
7A    CCF79.K=+CCF53.K+CCF78.K
```

TPA	=	Initial Planting Density (TPA is in trees per acre and the value is assigned by subprogram 5 of the forest growth model.)
CCF05.K	=	SWITCH Function Control Factor for 500 Trees per Acre
CCF15.K	=	SWITCH Function (CCF15.K is equal 1 if CCF05.K is equal 0 or CCF15.K is equal 0 if CCF05.K is not equal 0.)
SURP.K	=	Survival Percentage at the Current Computational Instant (SURP.K is computed by subprogram 5 of the forest growth model.)
CCF25.K	=	TABHL Function for Harvester Processing Time per Tree for 5 inch D.B.H. and Initial Planting Density of 500 Trees per Acre (CCF25.K is a function of SURP.K as computed by the harvester simulation model and recorded in Table 2.)
CCF35*	=	Processing Time per Harvestable Tree Data from Table 2

CCF42.K = Processing Time Term for 200 Trees per Acre, Initial Planting Density
CCF43.K = Processing Time Term for 300 Trees per Acre, Initial Planting Density
CCF44.K = Processing Time Term for 400 Trees per Acre, Initial Planting Density
CCF45.K = Processing Time Term for 500 Trees per Acre, Initial Planting Density
CCF46.K = Processing Time Term for 600 Trees per Acre, Initial Planting Density
CCF47.K = Processing Time Term for 700 Trees per Acre, Initial Planting Density
CCF48.K = Processing Time Term for 800 Trees per Acre, Initial Planting Density
CCF49.K = Processing Time Term for 900 Trees per Acre, Initial Planting Density
CCF50.K = Processing Time Term for 1,000 Trees per Acre, Initial Planting Density
CCF51.K = Sum of Processing Time Terms for 200, 300, and 400 Trees per Acre, Initial Planting Density
CCF52.K = Sum of Processing Time Terms for 500, 600, 700, 800, 900, and 1,000 Trees per Acre, Initial Planting Density
CCF53.K = Sum of all Processing Time Terms
CCF69.K = CLIP Function (CCF69.K is equal 0 when SURP.K is less than 0.725 or CCF69.K is equal 1 when SURP.K is equal to or greater than 0.725.)
CCF70.K = CLIP Function (CCF70.K is equal 0 when SURP.K is less than 0.775 or CCF70.K is equal -1.0 when SURP.K is equal to or greater than 0.775.)
DBH.K = Diameter at Breast Height at This Computational Instant (DBH.K is computed by subprogram 3 of the forest growth model.)
CCF71.K = TABHL Function for Processing Time per Tree Correctional Values Relative to D.B.H. and Survival Between 72.5 and 77.5 Percent (CCF71.K values are computed by the harvester simulation model and recorded in Table 3.)
CCF72* = Processing Time per Tree Correctional Data from Table 3.
CCF73.K = Survival/D.B.H. Correctional Values for Survival Percentages 72.5 to 77.5 (CLIP functions CCF69.K and CCF70.K work together to make CCF73.K equal CCF71.K when survival is in the range of 72.5 to 77.5 percent. The CLIP function makes CCF73.K equal 0 when survival is not in the range of 72.5 to 77.5 percent.)
CCF63.K = Survival/D.B.H. Correctional Values for Survival Percentages Less than 67.5 Percent
CCF68.K = Survival/D.B.H. Correctional Values for Survival Percentages of 67.5 to 72.5 Percent
CCF77.K = Survival/D.B.H. Correctional Values for Survival Percentages Greater than 77.5 Percent

CCF78.K = Sum of Survival/D.B.H. Correctional Values for the Four Survival Ranges
CCF79.K = Harvester Processing Time per Tree (CCF79.K is in seconds.)

The harvester processing time per tree (CCF79) is used to compute the time required to process a grapple load (CCF81). The trees per storage grapple load (CCF80) are computed as the product of cords per grapple load (CDPL) and harvestable trees per cord (VITC).

The cords per grapple load (CDPL) are computed by dividing the weight of a storage grapple load (LOAD) by the estimated weight per cord (CDWT). The weight of the storage grapple load (LOAD) is assigned 13,000 pounds due to the harvester design. The estimated cord weight (CDWT) is 5,400 pounds. The estimated cord weight (CDWT) of 5,400 pounds is based on data compiled by Taras (19).

The harvestable trees per cord (VITC) is computed by dividing the trees per cord at a 3 inch top (V3ITC) by the percentage of the tree that is harvestable (V3I70). The trees per cord at a 3 inch top (V3ITC) are computed by regression equations (16) in subprogram 12 of the forest growth model. The harvester can harvest only 50 feet of a tree in a single processing sequence. Trees are estimated to have 15 feet of tree above a 3 inch top. Therefore, trees over 65 feet are expected to have a merchantable stem of more than 50 feet long. Since trees are not expected to be much higher than 65 feet at optimal harvesting time, it is considered more economical not to recycle the harvester for the small volume of wood in tops of trees slightly over 65 feet in height. The percentage of merchantable wood in the 50 foot stem of a tree over 65 feet high is estimated by V3I70.

The percentage of merchantable tree volume that is harvestable (V3I70) is estimated by assuming that the tree is a right circular cone the height of the tree and there are 15 feet of top above the 3 inch diameter. The volume of a right circular cone is computed by the following equation:

Volume = (1/3)(Base)(Height)

The percentage of wood that is harvestable (V3I70) is computed by the following formula:

$$V3I70 = 1 - \frac{(\text{Volume above 50 Feet})-(\text{Volume in 15 Foot Top})}{(\text{Total Volume})-(\text{Volume in 15 Foot Top})}$$

The percentage of harvestable wood (V3I70) is manually computed for trees 65 to 100 feet high and is recorded in Table 9. The harvester can harvest all of the merchantable volume of trees less than 65 feet high. The values of V3I70 are programmed in the model by a TABHL function.

Computations for computing the grapple load processing time (CCF81) are summarized below:

```
C     CDWT=5,400
C     LOAD=13,000
20A   CDPL.K=LOAD.K/CDWT.K
58A   V3I70.K=TABHL(V3I71,HGH.K,65,100,1)
C     V3I71*=1.00/.9966/.9957/.9922/.9894/.9865/
              .9837/.9805/.9774/.9742/.9710/.9676/
              .9642/.9608/.9574/.9531/.9503/.9466/
              .9429/.9396/.9355/.9321/.9277/.9242/
              .9206/.9167/.9130/.9089/.9052/.9019/
              .8977/.8938/.8902/.8861/.8825/.8780
20A   VITC.K=V3ITC.K/V3I70.K
12A   CCF80.K=(VITC.K)(CDPL.K)
12A   CCF81.K=(CCF80.K)(CCF79.K)
```

CDWT = Weight per Cord in Pounds

Table 9. Percentage of Merchantable Stem That is Harvestable for Trees Over 65 Feet High

Tree Height (Feet)	Percentage of Merchantable Stem That is Harvestable	Tree Height (Feet)	Percentage of Merchantable Stem That is Harvestable
65	100	83	94.29
66	99.66	84	93.96
67	99.57	85	93.55
68	99.22	86	93.21
69	98.94	87	92.77
70	98.65	88	92.42
71	98.37	89	92.06
72	98.05	90	91.67
73	97.74	91	91.30
74	97.42	92	90.89
75	97.10	93	90.52
76	96.76	94	90.19
77	96.42	95	89.77
78	96.08	96	89.38
79	95.74	97	89.02
80	95.31	98	88.61
81	95.03	99	88.25
82	94.66	100	87.80

LOAD	=	Weight of a Grapple Load
CDPL.K	=	Cords per Grapple Load
V3I70.K	=	TABHL Function for Estimating Percentage of Merchantable Stem That is Harvestable for Trees over 65 Feet High
V3I71*	=	Values for TABHL Functions as Recorded in Table 9
HGH.K	=	Tree Height at This Computational Instant (HGH.K is in feet and is computed by subprogram 4 of the forest growth model.)
V3ITC.K	=	Trees per Cord Based on Merchantable Volume (V3ITC.K is computed on stem volume below a 3 inch top and V3ITC.K is computed by subprogram 12 of the tree growth model.)
VITC.K	=	Trees per Cord Based on Harvestable Volume
CCF80.K	=	Trees per Grapple Load
CCF79.K	=	Harvester Processing Time per Tree (CCF79.K is in seconds.)
CCF81.K	=	Grapple Load Processing Time

The harvester's operator is alerted by the harvester's hydraulic suspension system when a 13,000 pound load is supported by the harvester. After the load signal is given and after the shear is raised from the stump of the last tree, the operator moves the machine into position to deposit the load on the ground while the harvester automatically completes processing of the last tree in the load. The time to finish processing the last tree is computed by the harvester simulation model. These data, as a function of D.B.H., are recorded in Table 5. The time to process the grapple load and the time to deposit the load are added together to determine the total harvester operating time per load. Since the time to process the last tree is counted twice as dual time (CCF82), it is subtracted from the grapple load processing time (CCF81) to compute the effective grapple load processing time (CCF84). The dual time (CCF82) is made available to the economic model by a TABHL function.

The time required for the harvester to get into position and unload the grapple (CCF85) is the sum of: TWTI1, BUPT1, LMTI1, IGCT1, TWTI2, and RMTI1. TWTI1 is the estimated time (3 seconds) required to turn the harvester wheels. BUPT1 is the estimated time (10 seconds) required to back up 20 feet. LMTI1 is the estimated time (2 seconds) required to lower the machine. IGCT1 is the estimated time (1 second) required to initiate opening of the grapple. TWTI2 is the estimated time (6 seconds) required to turn wheels fully in the opposite direction. RMTI1 is the estimated time (4 seconds) required to raise the machine.

The time required for the total unloading sequence (CCF87) is the sum of: CCF86, BUPT2, TWTI3, IRGCT, PFWT1, and ILGCT. CCF86 is equal to the maximum of the time to position and unload the grapple (CCF85) or the time to complete processing of the last tree (CCF82). This is necessary because the unloading of the grapple cannot be completed until the processing of the last tree is complete and the grapple has been opened. BUPT2 is the estimated time (4 seconds) required to back up 8 feet. TWTI3 is the estimated time (6 seconds) required to turn the harvester wheels fully in the opposite direction. IRGCT is the estimated time (1 second) required to initiate closing of the grapple on the side toward the unharvested forest. PFWT1 is the estimated time (14 seconds) required to move the harvester forward 28 feet. ILGCT is the estimated time (1 second) required to initiate closing of the other half of the grapple.

The total harvester operating time, in seconds, per grapple load (CCF88) is the sum of the total unloading sequence time (CCF87) and the effective grapple load processing time (CCF84). The total harvester operating time per grapple load, in minutes, is computed by V3I14. The total harvester operating time per tree (CCF90) is also computed by dividing the total harvester operating time per grapple load (CCF88) by the total number of trees per grapple load (CCF89 which is equal CCF80 when CCF80 is equal to 1 or more).

The total harvesting cost per grapple load (V3I15) is computed by the product of the operating time per grapple load (V3I14 which is converted to hours) and the harvester operating cost per hour at harvesting time (E5). The harvester operating cost per hour at harvesting time (E5) is computed as a function of harvester operating cost per hour at planting time and economic factors such as inflation. The harvester operating cost per hour (E5) is computed by subprogram 19. The harvesting cost per cord at harvesting time (V3I16) is computed by dividing the harvesting cost per grapple load at harvesting time (V3I15) by the number of cords per grapple load (CDPL). The equivalent harvesting cost per cord at planting time (V3I62) is computed by dividing the harvesting cost per cord at harvesting time (V3I16) by an inflation factor (C5). The inflation factor (C5) is computed by subprogram 19.

The above computations are summarized below:

```
58A  CCF82.K=TABHL(CCF83,DBH.K,0.0,12.0,1.0)
C    CCF83*=28.2/28.2/28.2/28.2/28.2/28.2/28.2/28.2
           29.3/29.7/30.2/30.73/31.32
7A   CCF84.K=CCF81.K-CCF82.K
C    TWTI1=3
C    BUPT1=10
C    LMTI1=2
C    IGCT1=1
C    TWTI2=6
C    RMTI1=4
10A  CCF85.K=+TWTI1.K+BUPT1.K+LMTI1.K+IGCT1.K+TWTI2.K+RMTI1.K
56A  CCF86.K=MAX(+CCF85.K,+CCF82.K)
C    BUPT2=4
C    TWTI3=6
C    IRGCT=1
C    PFWT1=14
C    ILGCT=1
10A  CCF87.K=+CCF86.K+BUPT2.K+TWTI3.K+IRGCT.K+PFWT1.K+ILGCT.K
```

7A CCF88.K=CCF87.K+CCF84.K
20A V3I14.K=CCF88.K/60
51A CCF89.K=CLIP(CCF80.K,1.0,CCF80.K,1.0)
20A CCF90.K=CCF88.K/CCF89.K
44A V3I15.K=(E5.K)(V3I14.K)/60
20A V3I16.K=V3I15.K/CDPL.K
20A V3I62.K=V3I16.K/C5.K

DBH.K	=	D.B.H. at Current Computational Instant (DBH.K is computed by subprogram 3 of the forest growth model.)
CCF82.K	=	TABHL Function for Dual Time During Processing of Last Tree in a Grapple Load (The dual time values are determined by the harvester's simulation model and recorded in Table 5 as a function of D.B.H.)
CCF83*	=	Values for TABHL Function as Recorded in Table 5
CCF81.K	=	Grapple Load Processing Time
CCF84.K	=	Effective Grapple Load Processing Time
TWTI1	=	Time to Turn Harvester Wheel Fully in One Direction
BUPT1	=	Time to Back Harvester Up 20 Feet
LMTI1	=	Time to Lower the Harvester
IGCT1	=	Time to Initiate Opening of Grapple
TWTI2	=	Time to Turn Harvester Wheels from One Full Direction to the Opposite Full Direction
RMTI1	=	Time to Raise the Harvester
CCF85.K	=	Time to Position and Unload the Grapple
CCF86.K	=	Maximum of CCF85 or CCF82
BUPT2	=	Time to Back Harvester Up 8 Feet
TWTI3	=	Time to Turn Harvester Wheels from One Full Direction to the Opposite Full Direction
IRGCT	=	Time to Initiate Closing of One Side of Grapple
PFWT1	=	Time to Move Harvester Forward 20 Feet
ILGCT	=	Time to Initiate Closing of Other Half of Grapple
CCF87.K	=	Total Unloading Sequence Time
CCF88.K	=	Total Harvester Operating Time per Grapple Load, in Seconds
V3I14.K	=	Total Harvester Operating Time per Grapple Load, in Minutes
CCF89.K	=	CLIP Function (CCF89 is equal CCF80, tree per grapple load, when CCF80 is equal 1 or more. CCF89 is equal 1 when CCF80 is less than 1.)
CCF90.K	=	Harvester Operating Time per Tree (CCF90.K is in seconds.)
E5.K	=	Harvester Operating Cost per Hour at Harvesting Time (E5 is computed by subprogram 19.)
V3I15.K	=	Harvesting Cost per Grapple Load at Harvesting Time
CDPL.K	=	Cords per Grapple Load
V3I16.K	=	Harvesting Cost per Cord at Harvesting Time
C5.K	=	Inflation Factor Between Planting Time and Harvesting Time (C5.K is computed by subprogram 19.)
V3I62.K	=	Equivalent Harvesting Cost per Cord at Planting Time

Subprogram 14

This subprogram computes the initial value per acre (INV) of all investments and expenses required by the private landowner to grow trees to the harvesting age. INV is computed at planting time.

The initial investment is the land value at planting time (ILV). The land value is computed in subprogram 15 by TE1B2 as a function of the site index.

The initial expenses are site clearing cost (SPC1) and the combined site preparation and planting cost (SPPC). The site clearing cost (SPC1) is incurred during the initial plantation planting and is estimated at 20 dollars per acre. During replanting of plantations, the site clearing cost is not incurred because all previous trees were even aged and clear cut when harvested. The combined site preparation and planting cost (SPPC) is made up of site preparation cost (SPC), tree seedling cost (TC), and tree seedling planting cost (PC). Site preparation cost (SPC) is estimated at 12 dollars per acre. Tree seedling cost per acre (TC) is computed as a function of planting density per acre (TPA) and seedling cost (TCPT). Tree seedling cost (TCPT) is estimated at 4 dollars per 1,000 trees. The tree seedling planting cost per acre (PC) is computed as a function of planting density per acre (TPA) and planting cost (PCPT). Planting cost (PCPT) is estimated at 15 dollars per 1,000 trees.

The follow-on expenses are identified as annual taxes and annual management expenses. These expenses are expected to increase annually due to economic factors such as inflation. These follow-on expenses are assumed to be invested at planting time at typical bank deposit rates (estimated at 5 percent based on interest rates at the time of this work) and remain on deposit until needed. Subprogram 17 computes the annual taxes at subsequent years after planting and discounts the value, at the bank deposit rate, to the related value at planting time. The discounted annual taxes are used to determine the cummulative annual tax cost (H3) at planting time. Subprogram 18 computes, in a similar manner, the annual management cost and the cummulative annual management cost (H4) at planting time.

The above computations are summarized below:

```
10A  INV.K=+ILV.K+SPPC.K+H3.K+H4.K+SPC1+0.0
6A   ILV.K=TE1B2.K
C    SPC1=20
8A   SPPC.K=SPC+TC.K+PC.K
C    SPC=12
44A  TC.K=(TPA)(TCPT.K)/1,000
C    TCPT=4
44A  PC.K=(TPA)(PCPT.K)/1,000
C    PCPT=15
```

INV.K	=	Initial Value at Planting Time of All Investments and Expenses Required to Grow an Acre of Trees to Harvesting Age
ILV.K	=	Land Value per Acre at Planting Time (ILV.K is equal TE1B2.K which is computed by subprogram 15.)
SPPC.K	=	Combined Site Preparation and Planting Cost per Acre
H3.K	=	Cummulative Annual Tax Cost per Acre Discounted to Value at Planting Time (H3.K is computed by subprogram 17.)
H4.K	=	Cummulative Annual Management Cost per Acre Discounted to Value at Planting Time (H4.K is computed by subprogram 18.)
SPC1	=	Site Clearing Cost per Acre
TE1B2.K	=	Land Value per Acre at Planting Time (TE1B2.K is computed by subprogram 15.)
SPC	=	Site Preparation Cost per Acre
TC.K	=	Tree Seedling Cost per Acre
PC.K	=	Tree Seedling Planting Cost per Acre
TPA	=	Initial Planting Density in Trees per Acre (TPA is assigned a value by subprogram 5 of the forest growth model.)
TCPT.K	=	Tree Seedling Cost per 1,000
PCPT	=	Tree Seedling Planting Cost per 1,000

Subprogram 15

Forest land value at planting time (TE1B2) is assigned values relative to the land site index. The land value at planting time (TE1B2) is assumed to linearly increase from 50 dollars per acre for land with a 40 site index to 90 dollars per acre for land with a 80 site index. The land is also expected to increase in value relative to time due to economic factors. The economic factors affecting land values are the miscellaneous inflation factor (TE1B1) and the inflation rate factor (D1).

The miscellaneous inflation factor (TE1B1) is assigned values by a TABLE function that is included in the model to specify land values at specific years after planting time. This factor can be used to account for special influences in conjunction with the inflation rate factor (D1), or it can be used to totally account for changes in land value. The special influences are economic factors such as surrounding land development. This work does not consider special cases of economic factors and the land is assumed to increase in value at a compound inflation rate (I1). In view of this, the miscellaneous inflation factor (TE1B1) is assigned a value of unity at all computational instants.

The inflation rate ratio (C1) is computed at an annual compound inflation rate (I1) of 3 percent. The inflation rate ratio at N years after planting time is computed by the following equation:

$$C1 = (1+I1)^N$$

A CLIP function is used to control the use of the compound inflation rate. The CLIP function is controlled by the value of LCCT. If use of the annual compound inflation rate is desired, LCCT is assigned a value greater than 5 and the CLIP function assigns D1 the value of C1. If use of the annual compound inflation rate is not desired, LCCT is assigned a value less than 5 and the CLIP function assigns D1 a value of 1.

The miscellaneous inflated land value (TE1) is computed as the product of the miscellaneous inflation factor (TE1B1) and the land value at planting time (TE1B2). The total inflated land value (E1) is computed as the product of the miscellaneous inflated land value (TE1) and the inflation rate factor (D1).

These computations are summarized as follows:

```
C     I1=.03
7A    A1.K=P+I1
29A   B1.K=(N.K)LOGN(A1.K)
28A   C1.K=(P)EXP(B1.K)
51A   D1.K=CLIP(+C1.K,+P,+LCCT,+5)
12A   E1.K=(D1.K)(TE1.K)
12A   TE1.K=(TE1B1.K)(TE1B2.K)
59A   TE1B1.K=TABLE(TE1V1,N.K,0,40,40)
C     TE1V1*=1/1
59A   TE1B2.K=TABLE(TE1V2,SITEI.K,40,80,10)
C     TE1V2*=50/60/70/80/90
C     LCCT=10
```

I1	=	Compound Annual Inflation Rate for Land Value
P	=	1 (Computational constant established by subprogram 1 of the forest growth model.)
A1.K	=	Computational Factor for B1.K
B1.K	=	Computational Factor for C1.K
N.K	=	Years Since Planting Time at Current Computational Instant (N.K is computed by subprogram 2 of the forest growth model.)
C1.K	=	Inflation Rate Ratio
D1.K	=	Inflation Rate Factor CLIP Function (D1.K is assigned the value of C1.K if LCCT is greater than 5 or D1.K is assigned a value of 1 if LCCT is less than 5.)
E1.K	=	Total Inflated Land Value at N Years After Planting Time
TE1.K	=	Miscellaneous Inflated Land Value
TE1B1.K	=	Miscellaneous Inflation Factor
TE1V1*	=	Miscellaneous Inflation Factors for Subsequent Years After Planting Time
TE1B2.K	=	Land Value at Planting Time

TE1V2*	=	Land Values at Planting Time Relative to Site Index
SITEI.K	=	Site Index of Land (Value is assigned by subprogram 1 of the forest growth model.)
LCCT	=	Control Factor for Use of Compound Inflation Rate

Subprogram 16

The stumpage price of wood (cost of unharvested wood) generally increases with time due to economic factors. The stumpage price, at subsequent years after planting, is considered a function of inflation and the stumpage price at planting time (TE2B2). The stumpage price at planting time (TE2B2) is approximated at 8 dollars per cord. Stumpage price inflation is determined by a miscellaneous inflation factor (TE2B1) and an inflation rate factor (D2).

The miscellaneous inflation factor (TE2B1) is assigned values by a TABLE function that is included in the model to specify stumpage prices at subsequent years after planting time. This factor can be used to account for special influences in conjunction with the inflation rate factor (D2); or it can be used to totally account for increases in the stumpage price. The special influences are considered to be caused by factors related to supply and demand. This work does not consider special cases of supply and demand, and the stumpage price is assumed to increase at an annual compound inflation rate (I2). In view of this, the miscellaneous inflation factor (TE2B1) is assigned a value of unity at all computational instants.

The inflation rate ratio (C2) is computed at an annual compound inflation rate (I2) of 3 percent. The inflation rate ratio, at N years after planting time, is computed by the following equation:

$$C2 = (1 + I2)^{N}$$

A CLIP function is used to control the use of the compound inflation rate. The CLIP function is controlled by the value of SPCT. If use of the annual compound inflation rate is desired, SPCT is assigned a value greater than 5 and the CLIP function assigns D2 the value of C2. If use of the annual compound inflation rate is not desired, SPCT is assigned a value less than 5 and the CLIP function assigns D2 a value of 1.

The miscellaneous inflated stumpage price (TE2) is computed as the product of the miscellaneous inflation factor (TE2B1) and the stumpage price at planting time (TE2B2). The total inflated stumpage price (E2) is computed as the product of the miscellaneous inflated stumpage price (TE2) and the inflation rate factor (D2).

The computations are summarized as follows:

```
C     I2=.03
7A    A2.K=P+I2
29A   B2.K=(N.K)LOGN(A2.K)
28A   C2.K=(P)EXP(B2.K)
51A   P2.K=CLIP(+C2.K,+P,+SPCT,+5)
12A   E2.K=(D2.K)(TE2.K)
12A   TE2.K=(TE2B1.K)(TE2B2.K)
59A   TE2B1.K=TABLE(TE2V1,N.K,0,40,40)
C     TE2V1*=1/1
C     TE2B2=8.00
C     SPCT=10
```

I2	=	Compound Inflation Rate for Stumpage Price
P	=	1 (Computational constant established by subprogram 1 of the forest growth model)
A2.K	=	Computational Factor for B2.K
B2.K	=	Computational Factor for C2.K
N.K	=	Years Since Planting at Current Computational Instant (N.K is computed by subprogram 2 of the forest growth model.)
C2.K	=	Inflation Rate Ratio
D2.K	=	Inflation Rate Factor CLIP Function (D2.K is assigned the value of C2.K if SPCT is greater than 5 or D2.K is assigned a value of 1 if SPCT is less than 5.)

E2.K	=	Total Inflated Stumpage Price at Current Computational Instant
TE2.K	=	Miscellaneous Inflated Stumpage Price
TE2B1.K	=	Miscellaneous Inflation Factor
TE2V1*	=	Miscellaneous Inflation Factors for Subsequent Years After Planting Time
TE2B2	=	Stumpage Price at Planting Time
SPCT	=	Control Factor for Use of Compound Inflation Rate

Subprogram 17

The annual property tax (E3) per acre of forest land is computed as a function of wood volume per acre (V3I4), miscellaneous inflation factor (TE3B1), and inflation rate factor (D3). The property tax is paid at the end of the applicable year at the rate determined at the beginning of the year. The tax years are assumed coincident with 1 year increments after planting.

The assessed value of forest land for taxation is based on the volume of wood (V3I4) on the land. The tax rate (TE3B2) on forest land, at planting time, is .50 of a dollar per acre per year if the land is estimated to have less than 250 cubic feet of wood per acre. If there are an estimated 250 to 4,000 cubic feet of wood per acre, the tax rate is placed at 1 dollar per acre per year. For land with more than 4,000 cubic feet of wood per acre, the tax rate is 1.50 dollars per acre per year. These annual tax rates are based on typical property tax rates on forest land in Middle Georgia at the time of this work.

The miscellaneous inflation factor (TE3B1) is assigned values by a TABLE function that is included in the model to specify tax rates at subsequent years after planting time. This factor can be used to account for special influences in conjunction with the inflation rate factor (D3), or it can be used to totally account for inflation of taxes. The special influences are to be used to account for influences such as local economic developments. This work does not consider special cases of inflation and the tax rate is assumed to increase at an annual compound inflation rate (I3). In view of this, the miscellaneous inflation factor (TE3B1) is assigned a value of unity at all computational instants.

The inflation rate ratio (C3) is computed at an annual compound inflation rate (I3) of 3 percent. The inflation ratio at N years after planting time is computed by the following equation:

$$C3 = (1 + I3)^N$$

A CLIP function is used to control the use of the compound inflation rate. The CLIP function is controlled by the value of TRCT. If use of the annual compound inflation rate is desired, TRCT is assigned a value greater than 5 and the CLIP function assigns D3 the value of C3. If use of the annual compound inflation rate is not desired, TRCT is assigned a value less than 5 and the CLIP function assigns D3 a value of 1.

The miscellaneous inflated annual tax rate (TE3) is computed as the product of the miscellaneous inflation factor (TE3B1) and the tax rate (TE3B2) at planting time. The total inflated annual tax rate (E3) is computed as the product of the miscellaneous inflated annual tax rate (TE3) and the inflation rate factor (D3).

The annual taxes are invested at planting time at typical bank deposit rates (I10). The annual taxes (E3) remain on deposit until required. Subprogram 21 computes a discount factor (D10) to discount the total inflated annual tax rate (E3) to the related value (F3) at planting time. The discounted annual tax rate (F3) is delayed for 1 year (the next computational instant) to account for the taxes being paid at the end of the applicable year. The cummulated discounted annual tax (H3) is computed by summing the discounted total inflated annual tax rates (F3) after they have been delayed 1 computational interval.

These computations are summarized as follows:

```
C     I3=.03
7A    A3.K=P+I3
29A   B3.K=(N.K)LOGN(A3.K)
28A   C3.K=(P)EXP(B3.K)
51A   D3.K=CLIP(+C3.K,P,TRCT,+5)
12A   E3.K=(D3.K)(TE3.K)
12A   TE3.K=(TE3B1.K)(TE3B2.K)
59A   TE3B1.K=TABLE(TE3V1,N.K,0,40,40)
C     TE3V1*=1/1
59A   TE3B2.K=TABHL(TE3V2,V3I4.K,500,4000,250)
C     TE3V2*=0.50/1/1/1/1/1/1/1/1/1/1/1/1/1.50
12R   F3.KL=(E3.K)(D10.K)
1L    H3.K=H3.J+(DT)(+F3.JK+0)
6N    H3=0
C     TRCT=10
```

I3	=	Compound Annual Inflation Rate for Annual Tax Rate
P	=	1 (Computational constant established by subprogram 1 of the forest growth model.)
A3.K	=	Computational Factor for B3.K
B3.K	=	Computational Factor for C3.K
N.K	=	Years Since Planting at Current Computational Instant (N.K is computed by subprogram 2 of the forest growth model.)
C3.K	=	Inflation Rate Ratio
D3.K	=	Inflation Rate Factor CLIP Function (D3.K is assigned the value of C3.K if TRCT is greater than 5 or D3.K is assigned a value of 1 if TRCT is less than 5.)
E3.K	=	Total Inflated Annual Tax Rate at Current Computational Instant
TE3.K	=	Miscellaneous Inflated Annual Tax Rate
TE3B1.K	=	Miscellaneous Inflation Factor
TE3V1*	=	Miscellaneous Inflation Factors for Subsequent Years After Planting Time
TE3B2.K	=	TABHL Function for Tax Rate per Acre at Planting Time
TE3V2*	=	Tax Rate per Acre at Planting Time Relative to Wood Volume on the Land
V3I4.K	=	Wood Volume per Acre (V3I4.K is in cubic feet and is computed by subprogram 12 of the forest growth model.)
F3.KL	=	Discounted Annual Tax Rate

D10.K	=	Discount Factor (D10.K is computed by subprogram 21.)
H3.K	=	Cummulative Discounted Annual Tax at Current Computational Instant
TRCT	=	Control Factor for Use of Compound Inflation Rate

Subprogram 18

The annual management expense accounts for items such as inspection and treatment for disease and insects, fire protection, and management records. The management cost is computed at the beginning of the applicable years. The annual management expense funds are made available at the beginning of the applicable years. Forest management cost at planting time (TE4B2) is estimated at 1.50 dollars per acre. The forest management cost is increased at subsequent years due to the miscellaneous inflation factor (TE4B1) and the inflation rate factor (D4). The annual management cost (E4) is computed for the next computational instant. The management cost is made available at the beginning of the applicable year and expended between the applicable year and the next year.

The miscellaneous inflation factor (TE4B1) is assigned values by a TABLE function that is included in the model to specify management cost at subsequent years after planting time. This factor can be used to account for special influences in conjunction with the inflation rate factor (D4), or it can be used to totally account for increases in annual management cost. The special influences are to be used to account for costs such as the treatment of abnormal disease or insect infestation. This work does not consider special cases and the annual management cost is assumed to increase at an annual compound inflation rate (I4). In view of this, the miscellaneous inflation factor (TE4B1) is assigned a value of unity at all computational instants.

The inflation rate ratio (C4) is computed at an annual compound inflation rate (I4) of 3 percent. The inflation ratio, at N1 years (the next computational instant) after planting time, is computed by the following equation:

$$C4 = (1 + I4)^{N1}$$

A CLIP function is used to control the use of the compound inflation rate. The CLIP function is controlled by the value of MCCT. If use of the annual compound inflation rate is desired, MCCT is assigned a value greater than 5 and the CLIP function assigns D4 the value of C4. If use of the annual compound inflation rate is not desired, MCCT is assigned a value less than 5 and the CLIP function assigns D4 a value of 1.

The miscellaneous inflated annual management cost (TE4) is computed as the product of the miscellaneous inflation factor (TE4B1) and the management cost (TE4B2) at planting time. The total inflated annual management cost (E4) is computed as the product of the miscellaneous inflated annual management cost (TE4) and the inflation rate factor (D4).

The annual management cost is invested at planting time at typical bank deposit rates (I10). The annual management cost (E4) remains on deposit until required. Subprogram 21 computes a discount factor (D10) to discount the total inflated annual management cost (E4) to the related value (F4*1) at planting time. The discounted annual management cost (F4*1) is computed for the next computational instant. The discounted annual management cost at the next computational instant (F4*1) is delayed 1 computational interval to compute the discounted annual management cost at the current computational instant (G4). The annual management cost is made available at the beginning of the applicable year and expended between the applicable year and the next year. Therefore, the discounted annual management cost at the current computational instant (G4) is delayed 1 computational interval and added to the cummulative discounted annual management cost (H4).

These computations are summarized as follows:

```
C     I4=.03
7A    A4.K=P+I4
29A   B4.K=(N1.K)LOGN(A4.K)
28A   C4.K=(P)EXP(B4.K)
51A   D4.K=CLIP(+C4.K,P,MCCT,+5)
12A   E4.K=(D4.K)(TE4.K)
12A   TE4.K=(TE4B1.K)(TE4B2.K)
59A   TE4B1.K=TABLE(TE4V1,N1.K,1,41,40)
C     TE4V1*=1/1
C     TE4B2=1.50
C     MCCT=10
12A   F4*1.K=(E4.K)(D10.K)
37B   F4.K=BOXLIN(2,1)
C     F4*=1.50/1.50
6R    G4.KL=F4*2.K
1L    H4.K=H4.J+(DT)(+G4.JK+0)
```

I4	=	Compound Annual Inflation Rate for Annual Management Cost
P	=	1 (Computational constant established by subprogram 1 of the forest growth model.)
A4.K	=	Computational Factor for B4.K
B4.K	=	Computational Factor for C4.K
N1.K	=	Years Since Planting at the Next Computational Instant (N1.K is computed by subprogram 2 of the forest growth model.)
C4.K	=	Inflation Rate Ratio
D4.K	=	Inflation Rate Factor CLIP Function (D4.K is assigned the value of C4.K if MCCT is greater than 5 or D4.K is assigned a value of 1 if MCCT is less than 5.)
E4.K	=	Total Inflated Annual Management Cost at Next Computational Instant
TE4.K	=	Miscellaneous Inflated Annual Management Cost
TE4B1.K	=	Miscellaneous Inflation Factor
TE4V1*	=	Miscellaneous Inflation Factors for Subsequent Years after Planting Time
TE4B2	=	Annual Management Cost per Acre at Planting Time

F4*1.K	=	Discounted Annual Management Cost at the Next Computational Instant
F4.K	=	Helps F4*2.K Delay F4*1.K Values 1 Computational Interval
F4*2.K	=	Helps F4.K Delay F4*1.K Values 1 Computational Interval
F4*	=	Initial Values of F4.K
D10.K	=	Discount Factor (D10.K is computed by subprogram 21.)
G4.KL	=	Discounted Annual Management Cost at the Current Computational Instant
H4.K	=	Cummulative Discounted Annual Management Costs Expended at Current Computational Instant
MCCT	=	Control Factor for Use of Compound Inflation Rate

Subprogram 19

The proposed harvester operating cost at planting time (TE5B2) is estimated to be 30 dollars per hour. Computation of this operating cost is summarized in Appendix II. The estimated harvester operating cost, at planting time, is based on current component costs, their related operating cost, and current harvester assembly cost at planting time. The harvester operating cost at subsequent years after planting time (E5) is expected to increase relative to the miscellaneous inflation factor (TE5B1) and the inflation rate factor (D5).

The miscellaneous inflation factor (TE5B1) is assigned values by a TABLE function that is included in the model to specify harvester operating cost at subsequent years after planting time. This factor can be used to account for special influences in conjunction with the inflation rate factor (D5), or it can be used to totally account for increases in the harvester operating cost. The special influences can be abnormal fluctuations in the national economy which affect the inflation rate. This work does not consider special cases and the harvester operating cost is assumed to increase at an annual compound inflation rate (I5). In view of this, the miscellaneous inflation factor (TE5B1) is assigned a value of unity at all computational instants.

The inflation rate ratio (C5) is computed at an annual compound inflation rate (I5) of 3 percent. The inflation ratio, at N years after planting time, is computed by the following equation:

$$C5 = (1 + I5)^N$$

A CLIP function is used to control the use of the compound inflation rate. The CLIP function is controlled by the value of MOCT. If use of the annual compound inflation rate is desired, MOCT is assigned a value greater than 5 and the CLIP function assigns D5 the value of C5. If use of the annual compound inflation rate is not desired, MOCT is assigned a value less than 5 and the CLIP function assigns D5 a value of 1.

The miscellaneous inflated harvester operating cost (TE5) is computed as the product of the miscellaneous inflation factor (TE5B1) and the harvester operating cost at planting time (TE5B2). The total inflated harvester operating cost (E5) is computed as the product of the miscellaneous inflated harvester operating cost (TE5) and the inflation rate factor (D5). All of the above harvester operating costs are hourly rates.

These computations are summarized as follows:

```
C     I5=.03
7A    A5.K=P+I5
29A   B5.K=(N.K)LOGN(A5.K)
28A   C5.K=(P)EXP(B5.K)
51A   D5.K=CLIP(+C5.K,P,MOCT,+5)
12A   E5.K=(D5.K)(TE5.K)
22A   TE5.K(TE5B1.K)(TE5B2.K)
59A   TE5B1.K=TABLE(TE5V1,N.K,0,40,40)
C     TE5V1*=1/1
C     TE5B2=30.00
```

C MOCT=10

I5	=	Compound Annual Inflation Rate for Harvester Operating Cost
P	=	1 (Computational constant established by subprogram 1 of the forest growth model.)
A5.K	=	Computational Factor for B5.K
B5.K	=	Computational Factor for C5.K
N.K	=	Years Since Planting at Current Computational Instant (N.K is computed by subprogram 2 of the forest growth model.)
C5.K	=	Inflation Rate Ratio
D5.K	=	Inflation Rate Factor CLIP Function (D5.K is assigned the value of C5.K if MOCT is greater than 5 or D5.K is assigned a value of 1 if MOCT is less than 5.)
E5.K	=	Total Inflated Harvester Operating Cost per Hour at Current Computational Instant
TE5.K	=	Miscellaneous Inflated Harvester Operating Cost per Hour
TE5B1.K	=	Miscellaneous Inflation Factor
TE5V1*	=	Miscellaneous Inflation Factors for Subsequent Years after Planting Time
TE5B2	=	Harvester Operating Cost per Hour at Planting Time
MOCT	=	Control Factor for Use of Compound Inflation Rate

Subprogram 20

The harvesting cost per cord is a function of tree and forest characteristics. In view of this, an allowance is made for the harvesting cost per cord (V3I16 computed by subprogram 13). When this price (V3I16) exceeds the inflated harvesting cost per cord allowance at harvesting time (E6), the stumpage price at harvesting time (E2 computed by subprogram 16) is reduced accordingly by subprogram 22 which computes an adjusted stumpage price at harvesting time (V3I22). When the harvesting cost is less than the allowance, the stumpage price is increased accordingly. The harvesting cost allowance at planting time (TE6B2) is placed at 1.50 dollars per cord. The harvesting cost allowance at subsequent years after planting time (E6) is increased relative to the miscellaneous inflation factor (TE6B1) and the inflation rate factor (D6).

The miscellaneous inflation factor (TE6B1), that is assigned values by a TABLE function, is included in the model to specify harvesting cost allowance at subsequent years after planting time. This factor can be used to account for special influences in conjunction with the inflation rate factor (D6), or it can be used to totally account for increases in harvesting cost allowance. The special influences can be used to account for the affects of abnormal terrain and abnormal fluctuations in the economy. This work does not consider special cases and the harvesting cost allowance is assumed to increase at an annual compound inflation rate (I5). In view of this, the miscellaneous inflation factor (TE6B1) is assigned a value of unity at all computational instants.

The inflation rate ratio (C5) for the harvester operating cost (computed by subprogram 19) is used as the inflation rate ratio for the harvesting cost allowance at subsequent years after planting time. The harvester operating cost and the harvesting cost allowance increase at the same annual compound inflation rate.

A CLIP function is used to control the use of the compound inflation rate. The CLIP function is controlled by the value of HCCT. If use of the annual compound inflation rate is desired, HCCT is assigned a value greater than 5 and the CLIP function assigns D6 the value of C5. If use of the annual compound inflation rate is not desired, HCCT is assigned a value less than 5 and the CLIP function assigns D6 a value of 1.

The miscellaneous inflated harvesting cost allowance per cord (TE6) is computed as the product of the miscellaneous inflation factor (TE6B1) and the harvesting cost allowance per cord at planting time (TE6B2). The total inflated harvesting cost allowance per cord (E6) is computed as the product of the miscellaneous inflated harvesting cost allowance per cord (TE6) and the inflation rate factor (D6).

These computations are summarized as follows:

```
51A  D6.K=CLIP(+C5.K,P,HCCT,+5)
12A  E6.K=(D6.K)(TE6.K)
22A  TE6.K=(TE6B1.K)(TE6B2.K)
59A  TE6B1.K=TABLE(TE6V1,N.K,0,40,40)
C    TE6V1*=1/1
C    TE6B2=1.50
C    HCCT=10
```

P	=	1 (Computational constant established by subprogram 1 of the forest growth model.)
C5.K	=	Inflation Rate Ratio (C5.K is computed by subprogram 19.)
D6.K	=	Inflation Rate Factor CLIP Function (D6.K is assigned the value of C5.K if HCCT is greater than 5 or D6.K is assigned a value of 1 if HCCT is less than 5.)
E6.K	=	Total Inflated Harvesting Cost Allowance per Cord at Current Computational Instant
TE6.K	=	Miscellaneous Inflated Harvesting Cost Allowance per Cord
TE6B1.K	=	Miscellaneous Inflation Factor
TE6V1*	=	Miscellaneous Inflation Factors for Subsequent Years After Planting Time
N.K	=	Years Since Planting at Current Computational Instant (N.K is computed by subprogram 2 of the forest growth model.)
TE6B2	=	Harvesting Cost Allowance per Cord at Planting Time
HCCT	=	Control Factor for Use of Compound Inflation Rate

<u>Subprogram 21</u>

The follow-on forest expenses are identified as the annual tax and the annual management costs. In the case of the private landowner, these expenses are invested at planting time at typical bank deposit interest rates (I10). These funds remain on deposit until they are required each year. The initial value of the annual expenses is computed by discounting their value at subsequent years to the value at planting time.

The discount factor (D10) is computed at the bank deposit rate (I10).

Subprogram 17 computes the annual tax and the discounted value at planting time. The annual tax is computed at the beginning of applicable years. The annual tax remains on deposit until it is paid at the end of the applicable years (next computational instants).

Subprogram 18 computes the annual management cost and the discounted value at planting time. The annual management cost is computed for the next year (next computational instant) and then delayed until the next year (next computational instant).

The bank deposit rate (I10) is estimated at a 5 percent annual compound interest rate. This interest rate is based on typical bank deposit rates at the time of this work. The related discount factor (D10) at the next computational instant (N1) is computed by the following equation:

$$D10 = 1/(1 + I10)^{N1}$$

This discount factor (D10) is used by subprograms 17 and 18 to discount the annual tax and the annual management costs to their related values at planting time.

These computations are summarized as follows:

```
C     I10=.05
7A    A10.K=P+I10
29A   B10.K=(N1.K)LOGN(+A10.K)
28A   C10.K=(P)EXP(B10.K)
20A   D10.K=P/C10.K
```

I10	=	Compound Annual Interest Rate on Bank Deposits
P	=	1 (Computational constant established by subprogram 1 of the forest growth model.)
A10.K	=	Computational Factor for B10.K

B10.K	=	Computational Factor for C10.K
C10.K	=	Compound Interest Rate Ratio
D10.K	=	Discount Factor at Next Computational Instant

Subprogram 22

The private landowner's management objective for his forest is assumed to be the maximum rate of return on investment. The rate of return on investment is determined relative to harvesting cost and forest planning and management alternatives. The rate of return (V3I30) is computed from the ratio (V3I27) of the total asset value at subsequent years after planting (adjusted for harvesting cost) to the total value at planting time (NIV) of all investments and expenses.

The total asset value per acre (V3I24) at subsequent years after planting is the sum of the land value per acre (E1) and the harvestable yield value per acre adjusted for harvesting cost (V3I23). The land value per acre (E1) is computed by subprogram 15 as a function of inflation. The harvestable yield value per acre (V3I23) is computed as the product of the harvestable yield per acre (V3I60) and the stumpage price adjusted for harvesting cost (V3I22). The harvestable yield in cords per acre (V3I60) is computed by subprogram 12 of the forest growth model. The stumpage price adjusted for harvesting cost (V3I22) is computed as the sum of the total inflated stumpage price (E2) and the stumpage price adjustment term for harvesting cost (V3I21). The total inflated stumpage price (E2) is computed by subprogram 16. The stumpage price adjustment term for harvesting cost (V3I21) is computed as the difference between the total inflated harvesting cost allowance per cord (E6) and the harvesting cost per cord (V3I16). The total inflated harvesting cost allowance per cord

(E6) is computed by subprogram 19 and the harvesting cost per cord (V3I16) is computed by subprogram 13.

The initial value at planting time of all investments and expenses (INV) is computed by subprogram 14. INV values are used both where site clearance cost (SPC1) is and is not required.

The private landowner's rate of return (V3I30), when the forest is harvested N years after planting time, is computed by the following equation:

$$V3I30 = (V3I27)^{1/N} - 1$$

The computations for the landowner's rate of return (V3I30) are summarized as follows:

```
7A    V3I21.K=V3I16.K-E6.K
7A    V3I22.K=E2.K-V3I21.K
12A   V3I23.K=(V3I22.K)(V3I60.K)
7A    V3I24.K=E1.K+V3I23.K
20A   V3I27.K=V3I24.K/INV.K
51A   V3I32.K=CLIP(V3I27.K,1.0,V3I27.K,1.0)
29A   V3I28.K=(NIV.K)LOGN(V3I32.K)
28A   V3I29.K=(P)EXP(V3I28.K)
7A    V3I30.K=V3I29.K-P
```

V3I16.K	=	Harvesting Cost per Cord at Harvesting Time (V3I16.K is computed by subprogram 13.)
E6.K	=	Total Inflated Harvesting Cost Allowance per Cord at Harvesting Time (E6.K is computed by subprogram 20.)
V3I21.K	=	Stumpage Price Adjustment Term for Harvesting Cost
E2.K	=	Total Inflated Stumpage Price per Cord at Harvesting Time
V3I22.K	=	Stumpage Price per Cord Adjusted for Harvesting Cost at Harvesting Time
V3I23.K	=	Harvestable Yield Value per Acre at Harvesting Time
V3I60.K	=	Harvestable Yield in Cords per Acre at Harvesting Time (V3I60.K is computed by subprogram 12 of the forest growth model.)
E1.K	=	Total Inflated Land Value per Acre at Harvesting Time (E1.K is computed by subprogram 15.)
V3I24.K	=	Total Asset Value per Acre at Harvesting Time
V3I27.K	=	Ratio of Total Asset Value per Acre at Harvesting Time to Total Value per Acre of All Investments and Expenses at Planting Time

NIV.K	=	Total Value per Acre of All Investments and Expenses at Planting Time (NIV is computed by subprogram 14.)
V3I32.K	=	CLIP Function (V3I32.K is assigned the value of V3I27.K when V3I27.K is equal to or greater that 1 or V3I32.K is assigned a value of 1 when V3I27.K is less than 1.)
V3I28.K	=	Computational Factor for V3I29.K
V3I29.K	=	Computational Term for V3I30.K
P	=	1 (Computational constant is established by subprogram 1 of the forest growth model.)
V3I30.K	=	Private Landowner's Rate of Return on Forest Investment and Expenses

Subprogram 23

The paper company's management objective for its forest is assumed to be minimum wood cost. The paper company's cost of growing wood is determined relative to harvesting cost and forest planning and management alternatives. The wood cost per cord (CWC14), adjusted for harvesting cost relative to harvesting cost allowance, is computed as the sum of the stumpage price adjustment term for harvesting cost (V3I21) and the wood growing cost (CWC13). The paper company's wood cost is determined when funds are diverted into forest investments in lieu of industrial investments. Cases are considered where both site clearance is and is not required. The paper company's wood cost is also determined when the company borrows funds for forest investments and expenses as they are required. Site clearance is required for all the cases considered when funds are borrowed as needed.

The stumpage price adjustment term for harvesting cost (V3I21) is computed by subprogram 22. V3I21 is the difference (positive if V3I16 is more than E6 and negative for the converse) between harvesting cost per cord at planting time (V3I16 as computed by subprogram 13) and the harvesting cost allowance per cord at planting time (E6 as computed by subprogram 20.)

The wood growing cost per cord (CWC13) is computed by dividing the total growing cost per acre (CWC12) by the harvestable cords per acre (V3I60). V3I60 is computed by subprogram 12 of the forest growth model. The total wood growing cost per acre (CWC12) is the sum of initial investment and expenses per acre (CWC6), cummulative annual management cost expended per acre (CWC4*2), cummulative annual tax cost expended per acre (CWC1), and cummulative investment cost per acre (CWC11) minus the land value per acre at harvesting time (E1). The land value at harvesting time (E1) is deducted to compute the actual growing cost. The land value at planting time (E1) is computed by subprogram 15.

The initial investment and expenses per acre (CWC6) are the sum of the initial land value per acre at planting time (ILV), combined site preparation and planting cost per acre at planting time (SPPC), and site clearing cost per acre at planting time (SPC1). The initial land value at planting time (ILV) is computed by subprogram 15 as TE1B2 which is a function of the land site index. The combined site preparation and planting costs per acre at planting time is computed by subprogram 14 as the sum of the site preparation cost per acre (SPC), tree seedling cost per acre (TC), and tree seedling planting cost per acre (PC). The site clearing cost per acre at planting time (SPC1) is determined in subprogram 14.

The total inflated annual management cost at the next computational instant (E4) is computed by subprogram 18. Since this annual management cost (E4) is computed for the next computational instant, it is delayed to the next computational instant and added to the cummulative inflated annual management cost per acre required at the current computational instant (CWC2). The annual management cost is made available at the beginning of the applicable year and expended between the current computational instant (applicable year) and the next computational instant (next year). In view of this, the cummulative inflated annual management cost per acre required at the current computational instant (CWC2) is delayed to the next computational instant to determine the cummulative inflated annual management cost per acre (CWC4*2) expended at the current computational instant.

The total inflated annual tax rate per acre at the current computational instant (E3) is computed by subprogram 17. The annual tax rate is computed at the beginning of the applicable year and paid at the end of the year. In view of this, the total inflated annual tax rate per acre (E3) is delayed to the next computational instant and added to the cummulative annual tax cost to determine the cummulative inflated annual tax cost per acre (CWC1) at the current computational instant.

The cummulative investment cost per acre (CWC11) is determined by the cummulative interest on funds invested in the forest. The investment cost at the next computational instant (CWC9) is the product of the interest rate (CWC8) and the total investment value at the current computational instant (CWC7). The total investment value at the current computational instant (CWC7) is the sum of the initial investment and expenses per acre (CWC6), the combined cummulative tax and management cost expended at current computational instant (CWC5), and the cummulative interest at the current computational instant (CWC11).

The interest rate (CWC8) is assigned a value of 6 percent if the paper company borrows funds as needed for forest investments and expenses. The interest rate (CWC8) is assigned a value of 9 percent to represent lost profits after taxes if the paper company diverts funds from industrial investments into the forest.

The investment cost at the next computational instant (CWC9) is delayed until the next computational instant. The delayed values of CWC9 are added to the past cummulative interest to determine the cummulative interest at the current computational instant (CWC11).

These computations are summarized as follows:

```
6R   K3.KL=E3.K
51L  CWC1.K=CWC1.J+(DT)(K3.JK+0)
6N   CWC1=0
6R   K4.KL=E4.K
51L  CWC2.K=CWC2.J+(DT)(K4.JK+0)
6N   CWC2=1.50
6A   CWC4*1.K=CWC2.K
37B  CWC4.K=BOXLIN(2,1)
C    CWC4*=0/0
7A   CWC5.K=CWC1.K+CWC2.K
8A   CWC6.K=ILV.K+SPPC.K+SPC1.K
8A   CWC7.K=CWC6.K+CWC5.K+CWC11.K
12R  CWC9.KL=(CWC8.K)(CWC7.K)
C    CWC8=.06
51L  CWC11.K=CWC11.J+(DT)(CWC9.JK+0)
6N   CWC11=0
10A  CWC12.K=CWC6.K+CWC4*2.K+CWC1.K+CWC11.K-E1.K+0
20A  CWC13.K=CWC12.K/V3I60.K
7A   CWC14.K=CWC13.K+V3I21.K
```

E3.K	=	Total Inflated Annual Tax Rate per Acre at Current Computational Instant (E3.K is computed by subprogram 17.)
K3.KL	=	Tax Cost per Acre at Current Computational Instant (The tax cost at the current computational instant is the tax rate computed at the prior computational instant.)
CWC1.K	=	Cummulative Inflated Annual Tax Cost per Acre at the Current Computational Instant
E4.K	=	Total Inflated Annual Management Cost per Acre at the Next Computational Instant (E4.K is computed by subprogram 18.)

CWC2.K	=	Cummulative Inflated Annual Management Cost per Acre Required at the Current Computational Instant
CWC4*1.K	=	Helps CWC4.K and CWC4*2.K Delay CWC2.K Values 1 Computational Interval
CWC4.K	=	Helps CWC4*1.K and CWC4*2.K Delay CWC2.K Values 1 Computational Interval
CWC4*	=	Initial Values of CWC4.K
CWC4*2.K	=	Cummulative Inflated Annual Management Cost per Acre Expended at the Current Computational Instant
CWC5.K	=	Combined Cummulative Tax and Management Cost Expended at Current Computational Instant
CWC6.K	=	Initial Investments and Expenses per Acre at Planting Time
ILV.K	=	Initial Land Value per Acre at Planting Time (ILV.K is assigned the value of TE1B2 by subprogram 14 and TE1B2 is computed by subprogram 15.)
SPPC.K	=	Combined Site Preparation and Planting Cost per Acre at Planting Time (SPPC.K is computed by subprogram 14.)
SPC1	=	Site Clearing Cost per Acre at Planting Time (SPC1 value is assigned by subprogram 14.)
CWC7.K	=	Total Investment Value at the Current Computational Instant
CWC11.K	=	Cummulative Interest at the Current Computational Instant
CWC8	=	Interest Rate (CWC8 is the interest rate if funds are borrowed as needed or CWC8 is the profit loss rate if funds are diverted from industrial investments.)
CWC9.KL	=	Investment Cost at the Current Computational Instant
CWC12.K	=	Total Wood Growing Cost per Acre at Current Computational Instant
V3I60.K	=	Harvestable Yield in Cords per Acre at Harvesting Time (V3I60.K is computed by subprogram 12 of the forest growth model.)
E1.K	=	Land Value at Harvesting Time (E1.K is computed by subprogram 15.)
CWC13.K	=	Total Wood Growing Cost per Cord
V3I21.K	=	Stumpage Price Adjustment Term for Harvesting Cost (V3I21.K is computed by subprogram 22.)
CWC14.K	=	Total Wood Growing Cost per Cord Adjusted for Harvesting Cost Relative to Harvesting Cost Allowance

CHAPTER X

ECONOMIC MODEL EXPERIMENTATION AND RESULTS

The economic model is developed to economically evaluate the proposed harvester design in conjunction with forest planning and management alternatives relative to economically oriented management objectives by model experimentation.

The economic model experimentation is conducted for various forest planning and management alternatives to determine the independent landowner's rate of return, the paper company's wood cost, harvesting cost, productivity of the harvester, and related data for these alternatives. During the model experimentation, the initial planting density (TPA) is varied from 200 to 1,000 trees per acre in 100 trees per acre increments for site indices 40, 50, 60, 70, and 80. The harvesting age is varied from 0 to 40 years in 1 year increments for each of the planting densities on each site index.

The landowner's rate of return is computed for each of the forest planning and management alternatives when site clearance is required and when it is not required. The results are plotted for harvesting ages of 10 to 40 years and presented in figures as follows:

(1) Independent Landowner's Rate of Return on Forest Investment and Growing Cost (Site Clearance Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with: Site Index 40 is Figure 35, Site Index 50 is Figure 36, Site Index 60 is Figure 10,

Site Index 70 is Figure 37, and Site Index 80 is Figure 38.

(2) Independent Landowner's Rate of Return on Forest Investment and Growing Cost (Site Clearance Not Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with: Site Index 40 is Figure 39, Site Index 50 is Figure 40, Site Index 60 is Figure 11, Site Index 70 is Figure 41, and Site Index 80 is Figure 42.

The paper company's wood cost, adjusted for harvesting cost, is computed for each of the forest planning and management alternatives when the company diverts funds from industrial investments (9 percent expected profit) into forest investments. These computations are computed both when site clearance is required and when it is not required. The results are plotted for harvesting ages of 10 to 40 years and presented in figures as follows:

(1) Paper Company's Wood Growing Cost Utilizing Company Industrial Funds (Site Clearance Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with: Site Index 40 is Figure 43, Site Index 50 is Figure 44, Site Index 60 is Figure 12, Site Index 70 is Figure 45, and Site Index 80 is Figure 46.

(2) Paper Company's Wood Growing Cost Utilizing Company Industrial Funds (Site Clearance Not Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with: Site Index 40 is Figure 47, Site Index 50 is Figure 48, Site Index 60 is Figure 13, Site Index 70 is Figure 49, and Site Index 80 is Figure 50.

The paper company's wood cost is computed for each of the forest planning and management alternatives when the paper company borrows funds (at 6 percent interest) as they are required for forest investments and expenses. These computations are computed only when site clearance is required. The results are plotted for harvesting ages of 10 to 40 years and presented in figures as follows:

Paper Company's Growing Cost per Cord at 6 Percent Interest on Forest Investment and Growing Cost (Site Clearance Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with: Site Index 40 is Figure 51, Site Index 50 is Figure 52, Site Index 60 is Figure 14, Site Index 70 is Figure 53, and Site Index 80 is Figure 54.

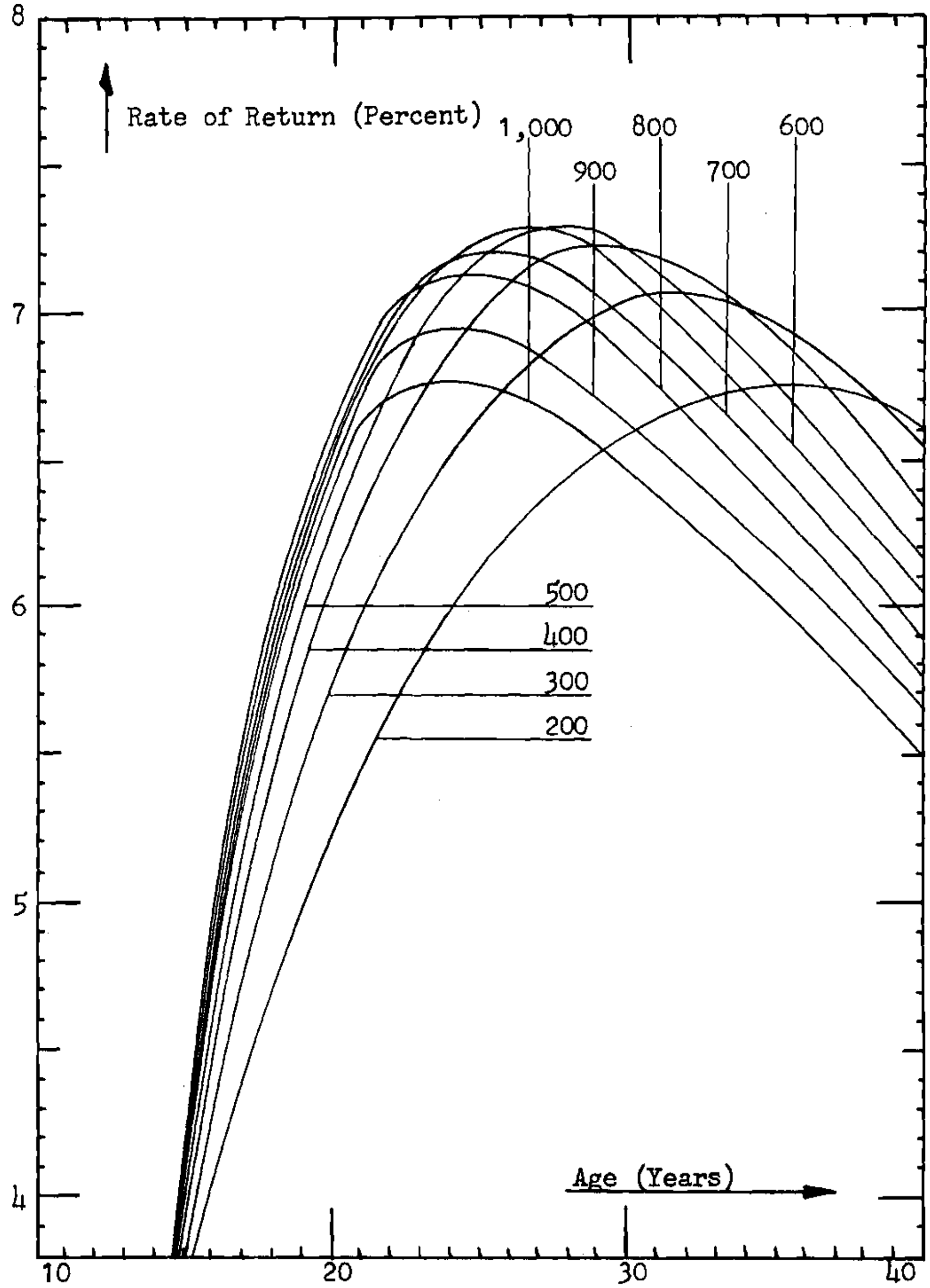


Figure 10. Independent Landowner's Rate of Return on Forest Investment and Growing Cost (Site Clearance Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 60

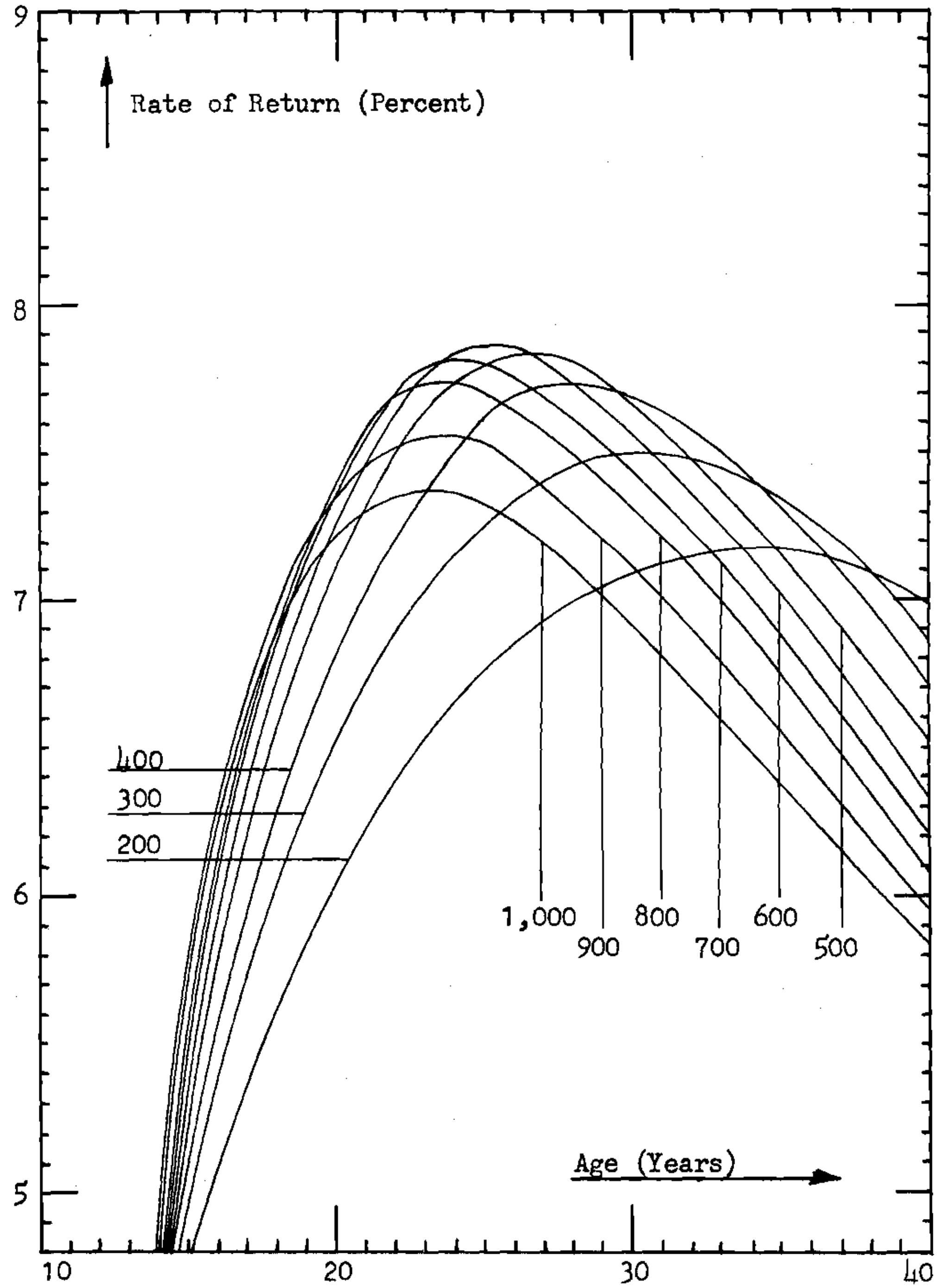


Figure 11. Independent Landowner's Rate of Return on Forest Investment and Growing Cost (Site Clearance Not Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 60

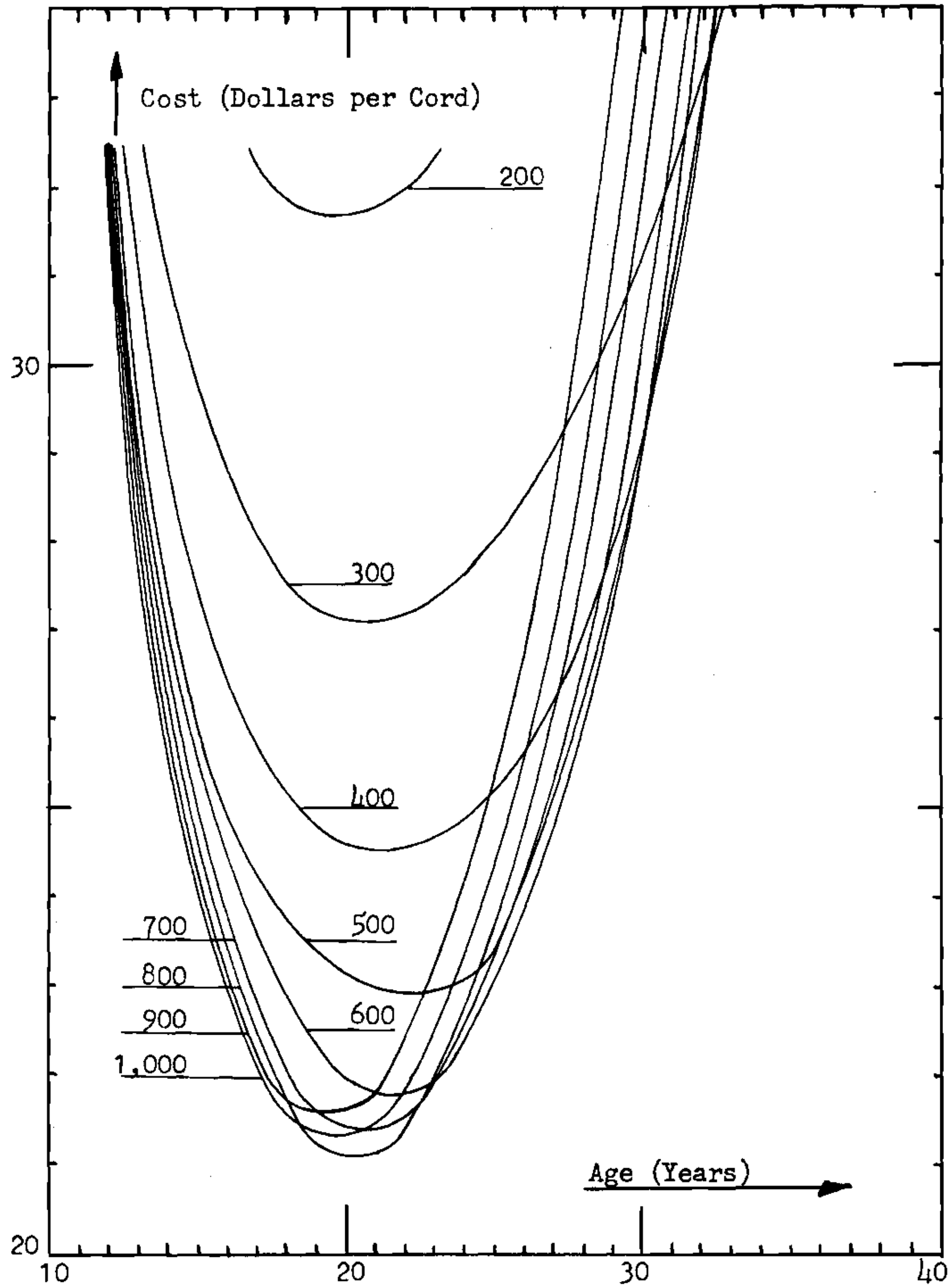


Figure 12. Paper Company's Wood Growing Cost Utilizing Company Industrial Funds (Site Clearance Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 60

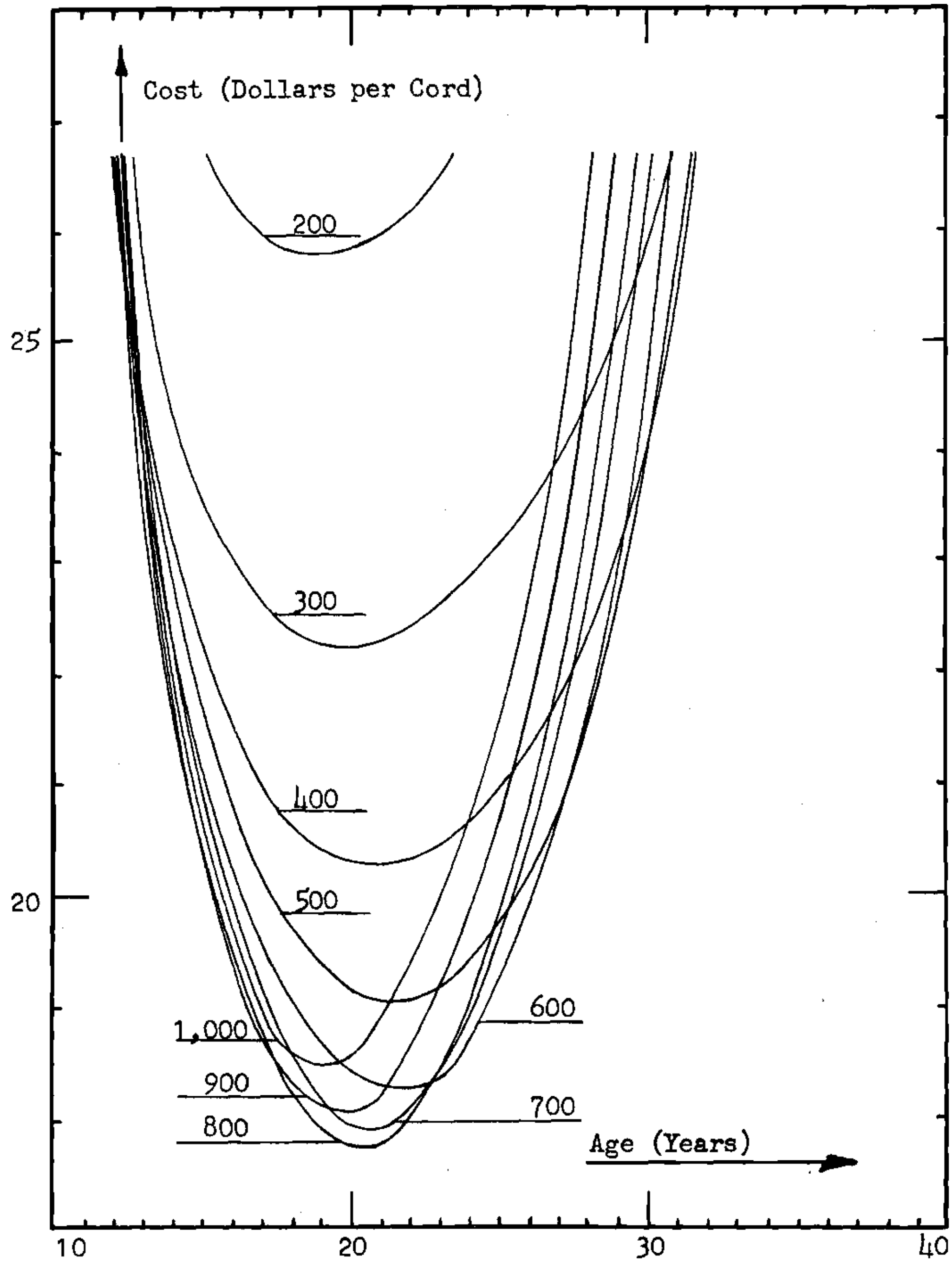


Figure 13. Paper Company's Wood Growing Cost Utilizing Company Industrial Funds (Site Clearance Not Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 60

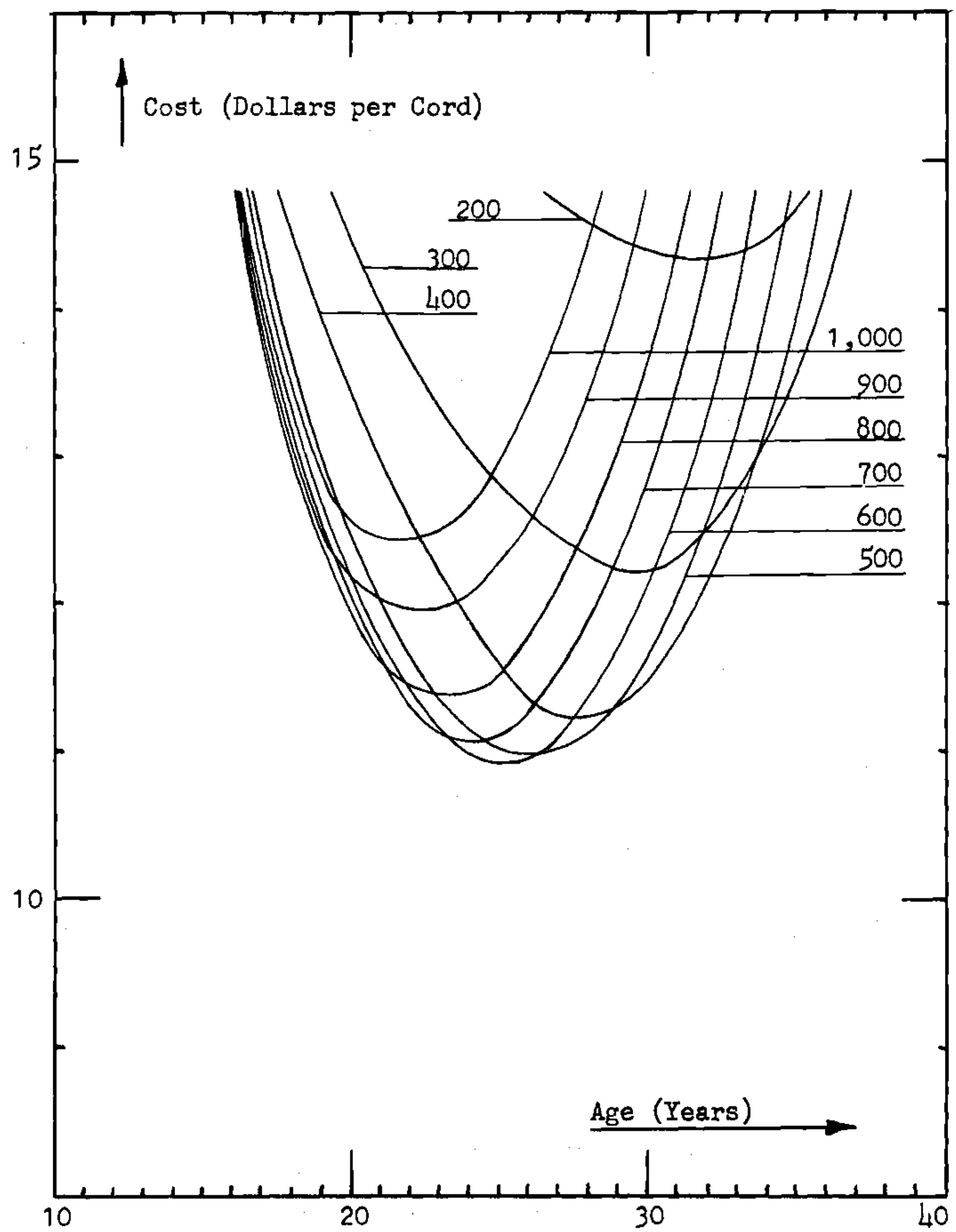


Figure 14. Paper Company's Wood Growing Cost per Cord at 6 Percent Interest on Investment and Growing Cost (Site Clearance Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 60

CHAPTER XI

DISCUSSION OF THE RESULTS

The harvester simulation model is used to determine the proposed harvester processing time per tree as a function of tree and forest characteristics (tree location and size). The results of the harvester simulation model experimentation are summarized in Tables 2 and 3.

The forest growth model is used to determine tree and forest characteristics (tree diameter, height, volume, weight, and distribution density) as a function of forest planning and management (planting density, site index, and tree age). The results of the forest growth model experimentation are summarized in Figures 4 through 9 and 15 through 34.

The economic model is used to economically evaluate the proposed harvester design in conjunction with forest planning and management alternatives. This economic model utilizes the results of the forest growth model to determine tree and forest characteristics related to forest planning and management alternatives. The results of the harvester simulation model are utilized to determine the harvesting cost related to the tree and forest characteristics. The economic model also determines forest growing cost and forest value related to the forest planning and management alternatives. The economic evaluation is based on the maximum rate of return on forest investments and growing cost for the private landowner and minimum wood growing cost for the paper company. The landowner's rate of return is determined relative to the forest planning and management alternatives where site clearing cost is both required and not required. The paper company's wood growing cost is determined relative to the forest planning and management alternatives when the paper company diverts industrial funds into forest investments and when the paper company borrows funds for forest investments. The paper company's wood growing cost (where funds are diverted from industrial investments) is determined for cases where site clearance is required and where it is not required. The paper company's wood growing cost (where funds are borrowed) is determined only for cases where site clearance is required. The results are summarized in Figures 10 through 14 and 35 through 54.

The data developed by the economic model are reviewed to identify the forest planning and management alternatives (in conjunction with the harvester design) that optimize the economic objectives of the independent landowner (maximum rate of return) and the paper company (minimum wood growing cost). The tree and forest characteristics, harvester performance and operating cost, and related economic data are identified relative to the optimal forest planning and management alternatives (initial planting and harvesting age related to site index). The data are summarized in Tables 10 through 14.

Data for the independent landowner with site index 40 are not presented in Tables 10 and 11 because the rates of return do not peak at 40 years (age limit of the simulation). Projections of the rate of return curves for site index 40 indicate the rates of return are less than 5 percent, which is considered a poor investment.

The land site index has a major affect on the rate of return and wood growing cost. The low site indices result in marginal rates of

Table 10. Summary of Data Related to Maximum Rate of Return for the Independent Landowner When Site Clearance Is Required

	Site Index 50	60	70	80
Maximum Rate of Return (Percent)	5.71	7.30	9.02	10.78
Harvesting Age (Years)	36	28	22	18
Initial Planting Density (Trees per Acre)	400	500	600	700
Survival at Harvesting Time (Percent)	66	70	74	76
Tree D.B.H. (Inches)	9.73	9.12	8.57	8.19
Tree Height (Feet)	58	63	65	66
Tree Weight (Pounds)	844	802	728	666
Harvestable Yield Average (Cord/Acre/Year)	1.15	1.86	2.71	3.64
Harvestable Yield Percentage of Maximum Yield	99	98	97	97
Harvester Operating Time (Seconds per Tree)	23	21	19	18
Man-Harvester Production Rate (Cords/ Man-Harvester Hour)	24.4	25.6	25.0	24.0
Harvesting Cost (Dollars per Cord)	3.56	2.68	2.30	2.13
Equivalent Harvesting Cost at Planting Time (Dollars per Cord)	1.23	1.17	1.20	1.25
Harvesting Cost Allowance (Dollars per Cord)	4.35	3.43	2.88	2.58
Stumpage Price at Harvesting Time (Dollars per Cord)	23.19	18.30	15.32	13.62
Adjusted Stumpage Price for Harvesting Cost (Dollars per Cord)	23.98	19.05	15.90	14.07
Change in Stumpage Price Due to Harvesting Cost (Percent)	+3.4	+4.1	+3.8	+3.3
Stumpage Price at Harvesting Time plus Harvesting Cost Allowance (Dollars per Cord)	27.54	21.73	18.20	16.20
Harvesting Cost Percentage of Combined Stumpage Price and Harvesting Allowance	12.9	12.3	12.62	13.15

Table 11. Summary of Data Related to Maximum Rate of Return for the Independent Landowner When Site Clearance Is Not Required

	Site Index			
	50	60	70	80
Maximum Rate of Return (Percent)	6.13	7.86	9.68	11.55
Harvesting Age (Years)	32	25	21	18
Initial Planting Density (Trees per Acre)	500	600	700	700
Survival at Harvesting Time (Percent)	68	72	74	76
Tree D.B.H. (Inches)	8.39	8.03	7.91	8.19
Tree Height (Feet)	56	60	64	66
Tree Weight (Pounds)	585	576	595	666
Harvestable Yield Average (Cord/Acre/Year)	1.15	1.83	2.71	3.64
Harvestable Yield Percentage of Maximum Yield	99	98	97	97
Harvester Operating Time (Seconds per Tree)	21	19	19	18
Man-Harvester Production Rate (Cords/ Man-Harvester Hour)	19.0	19.85	21.4	24.0
Harvesting Cost (Dollars per Cord)	4.06	3.16	2.60	2.13
Equivalent Harvesting Cost at Planting Time (Dollars per Cord)	1.58	1.51	1.40	1.25
Harvesting Cost Allowance (Dollars per Cord)	3.86	3.14	2.79	2.58
Stumpage Price at Harvesting Time (Dollars per Cord)	20.60	16.75	14.89	13.62
Adjusted Stumpage Price for Harvesting Cost (Dollars per Cord)	20.40	16.73	15.09	14.07
Change in Stumpage Price Due to Harvesting Cost (Percent)	-1.0	0	+1.29	+3.3
Stumpage Price at Harvesting Time plus Harvesting Cost Allowance (Dollars per Cord)	24.46	19.89	17.68	16.20
Stumpage Price and Harvesting Allowance	16.7	15.9	14.7	13.15

Table 12. Summary of Data Related to Minimum Wood Cost for the Paper Company When Site Clearance is Required and the Paper Company Utilizes Industrial Funds for Forest Investments and Growing Expenses

	Site Index				
	40	50	60	70	80
Minimum Wood Cost Adjusted for Harvester Cost (Dollars per Cord)	80.51	37.52	21.04	13.06	8.60
Harvesting Age (Years)	24	21	20	19	18
Initial Planting Density (Trees per Acre)	800	900	800	800	700
Survival at Harvesting Time (Percent)	72	73	74	75	76
Tree D.B.H. (Inches)	5.12	5.55	6.49	7.19	8.19
Tree Height (Feet)	39	45	53	60	66
Tree Weight (Pounds)	114	175	310	450	666
Harvestable Yield Average (Cords/Acre/Year)	.51	1.02	1.71	2.63	3.64
Harvestable Yield Percentage of Maximum Yield	88	87	90	94	95
Harvester Operating Time (Seconds per Tree)	16	16	17	18	18
Man-Harvester Production Rate (Cords/Man-Harvester Hour)	4.64	7.2	12.15	17.15	24.0
Harvesting Cost (Dollars per Cord)	13.19	7.75	4.46	3.65	2.13
Equivalent Harvesting Cost at Planting Time (Dollars per Cord)	6.47	4.17	2.47	1.75	1.25
Harvesting Cost Allowance (Dollars per Cord)	3.05	2.79	2.71	2.63	2.58
Stumpage Price at Harvesting Time (Dollars per Cord)	16.29	14.89	14.43	14.02	13.62
Wood Growing Cost Adjusted for Harvesting Cost plus Harvesting Cost Allowance (Dollars per Cord)	83.56	40.31	23.75	15.69	11.18
Harvesting Cost Percentage of Combined Wood Growing Cost Adjusted for Harvesting Cost plus Harvesting Cost Allowance	15.8	19.3	18.8	23.3	19.1

Table 13. Summary of Data Related to Minimum Wood Cost for the Paper Company When Site Clearance Is Not Required and the Paper Company Utilizes Industrial Funds for Forest Investments and Growing Expenses

	Site Index				
	40	50	60	70	80
Minimum Wood Cost Adjusted for Harvesting Cost (Dollars per Cord)	67.37	31.71	17.76	11.00	7.16
Harvesting Age (Years)	23	21	20	20	18
Initial Planting Density (Trees per Acre)	700	800	800	700	700
Survival at Harvesting Time (Percent)	74	74	74	75	76
Tree D.B.H. (Inches)	5.16	5.71	6.49	7.70	8.19
Tree Height (Feet)	38	45	53	62	66
Tree Weight (Pounds)	112	188	310	543	666
Harvestable Yield Average (Cords/Acre/Year)	.47	.98	1.71	2.63	3.64
Harvestable Yield Percentage of Minimum Yield	74	85	90	94	97
Harvester Operating Time (Seconds per Tree)	17	17	17	18	18
Man-Harvester Production Rate (Cords/Man-Harvester Hour)	4.55	7.6	12.15	19.85	24
Harvesting Cost (Dollars per Cord)	13.02	7.32	4.46	2.72	2.13
Equivalent Harvesting Cost at Planting Time (Dollars per Cord)	6.60	3.94	2.47	1.51	1.25
Harvesting Cost Allowance (Dollars per Cord)	2.96	2.79	2.71	2.71	2.58
Stumpage Price at Harvesting Time (Dollars per Cord)	15.79	14.89	14.43	14.43	13.62
Wood Growing Cost Adjusted for Harvesting Cost plus Harvesting Cost Allowance (Dollars per Cord)	70.33	34.50	20.47	13.71	9.74
Harvesting Cost Percentage of Combined Wood Growing Cost Adjusted for Harvesting Cost plus Harvesting Cost Allowance	18.6	21.2	21.8	19.8	21.9

Table 14. Summary of Data Related to Minimum Wood Cost for the Paper Company When Site Clearance is Required and the Paper Company Borrows Funds for Forest Investments and Growing Expenses

	Site Index				
	40	50	60	70	80
Minimum Wood Cost Adjusted for Harvesting Cost (Dollars per Cord)	42.68	20.10	10.91	6.41	4.18
Harvesting Age (Years)	29	27	25	22	21
Initial Planting Density (Trees per Acre)	700	600	600	600	600
Survival at Harvesting Time (Percent)	69	71	72	74	74
Tree D.B.H. (Inches)	5.88	7.14	8.03	8.57	9.40
Tree Height (Feet)	43	52	60	65	73
Tree Weight (Pounds)	188	378	576	728	993
Harvestable Yield Average (Cords/Acre/Year)	.58	1.10	1.83	2.70	3.66
Harvestable Yield Percentage Maximum Yield	90	95	97	97	98
Harvester Operating Time (Seconds per Tree)	18	18	19	19	20
Man-Harvester Production Rate (Cords/Man-Harvester Hour)	7.15	13.6	19.85	25.0	32.2
Harvesting Cost (Dollars per Cord)	9.90	4.90	3.16	2.30	1.73
Equivalent Harvesting at Planting Time (Dollars per Cord)	4.20	2.20	1.51	1.20	.93
Harvesting Cost Allowance (Dollars per Cord)	3.53	3.34	3.14	2.88	2.79
Stumpage Price at Harvesting Time (Dollars per Cord)	18.82	17.80	16.75	15.32	14.89
Wood Growing Cost Adjusted for Harvesting Cost plus Harvesting Cost Allowance (Dollars per Cord)	46.21	23.44	14.05	9.29	6.97
Harvesting Cost Percentage of Combined Wood Growing Cost Adjusted for Harvesting Cost plus Harvesting Cost Allowance	21.5	20.9	22.5	24.8	24.8

return and unacceptable growing costs; whereas the high site indices produce very good rates of return and low wood growing costs.

When the paper company utilizes industrial funds (which have an expected annual profit rate of 9 percent after taxes) for forest investments and growing expenses, the paper company's wood growing cost (adjusted for harvesting cost) exceeds the stumpage price at harvesting time for site indices below 70. In this case, it costs the paper company more to grow the wood than to buy wood from the independent landowner at the current stumpage price; therefore, it is considered desirable for the paper company to only invest in forests with site indices 70 to 80 when funds are diverted from industrial investments.

When the paper company borrows funds (at an annual interest rate of 6 percent) for forest investments and expenses, the growing cost exceeds the current stumpage price for site indices less than 60. In view of this, it is not desirable for the paper company to grow wood on site indices less than 60 when borrowed funds are being invested in the forest.

The site clearing cost alters the landowner's rate of return by approximately 7 percent. The paper company's wood growing cost is changed approximately 12 percent by site clearing cost.

The optimal harvesting age varies from 18 to 36 years. The site index has the major influence on the optimal harvesting age.

The optimal planting densities vary from 400 to 800 trees per acre. The optimal planting density for the independent landowner increases as the site index increases; whereas the optimal planting density for the paper company is not as closely related to the site index.

The maximum wood yield is not greatly reduced at the optimal forest planning and management alternatives for the economically oriented management objectives. The wood yield at all recommended alternatives is at least 94 percent of the maximum yield.

The harvesting cost (at recommended forest planning and management alternatives) varies from 1.73 to 4.06 dollars per cord. The equivalent harvesting cost at planting time (equivalent current cost) is .93 to 1.58 dollars per cord. This is a significant reduction in harvesting cost as compared to the current harvesting cost of the Buschcombine that is reported (20) to be 5.70 dollars per cord. In the case of the independent landowner, the harvesting cost comprises 12.9 to 16.7 percent of the combined stumpage price and harvesting cost allowance. In the case of the paper company, the harvesting cost comprises 19.1 to 24.8 percent of the combined wood growing cost (adjusted for harvesting cost) and harvesting cost allowance.

The man-harvester production rate varies from 17.15 to 32.2 cords per hour (at recommended forest planning and management alternatives). This is a significant increase over current man-machine production rates.

The tree characteristics (related to the recommended forest planning and management alternatives) are 7.19 to 9.73 inches for tree D.B.H., 56 to 73 feet for tree height, and 450 to 993 pounds for tree weight. The harvester design should be refined for these tree characteristics.

The economic model data are reviewed to determine the sensitivity of the landowner's rate of return and the paper company's wood growing cost relative to variations from the optimal harvesting age. Data are reviewed for 5 years around the optimal harvesting age. The planting density is maintained at the optimal planting density at the optimal harvesting age. The cases considered are for the landowner and paper company (funds borrowed) where site clearance is required for site indices 60 and 80. The related data are summarized and presented in Tables 15 through 18. These data are used to determine the variance in harvesting age that maintains the rate of return and wood growing cost within 2 percent of the optimal values. With this goal, the independent landowner's harvesting age can vary from -4 to +3 years for site index 60 and from -1.5 to +2 years for site index 80. In the case of the paper company, the harvesting age can vary ± 2 years for site index 60 and ± 1.5 years for site index 80. The rate of return and wood growing cost change at an increasing rate as the harvesting age changes from the optimal age.

The percentage change in harvesting cost is also analyzed as the harvesting age is changed from the optimal age. The percentage change in harvesting cost is found to be at least 5 times greater than the change in the rate of return and the wood growing cost when variance of these objectives is maintained within 2 percent of the optimal values.

The economic model data are also reviewed to determine the sensitivity of the landowner's rate of return and the paper company's wood growing cost relative to variations from the optimal planting density. The data are reviewed at the optimal harvesting age at planting densities of 200 to 1,000 trees per acre. The data are reviewed for the landowner and paper company (funds borrowed) where site clearance is required for site indices 60 and 80. The related data are summarized and presented in Tables 19 through 22. In all cases reviewed, the planting density

Table 15. Sensitivity of the Independent Landowner's Rate of Return (Site Clearance Required) to Variations from the Optimal Harvesting Age for Site Index 60 at the Optimal Planting Density of 500 Trees per Acre

Harvesting Age (Years)	Rate of Return (Percent)	Percent of Maximum Rate of Return	Tree D.B.H. (Inches)	Tree Weight (Pounds)	Tree Height (Feet)	Equivalent Harvesting Cost at Planting Time (Dollars per Cord)	Percentage Change in Harvesting Cost Relative to Cost at Optimal Age
23	6.9865	95.8	7.97	540	57.5	1.61	+37.5
24	7.1156	97.6	8.22	592	58.7	1.49	+27
25	7.2081	98.9	8.46	645	60.0	1.39	+19
26	7.2663	99.6	8.69	698	61.1	1.30	+11
27	7.2955	99.9	8.91	751	62.2	1.23	+5
28*	7.2964	100.0	9.12	802	63.2	1.17	0
29	7.2731	99.7	9.31	851	64.2	1.13	-3.5
30	7.2217	99.0	9.48	898	65.1	1.09	-7
31	7.1371	97.8	9.63	943	66.0	1.06	-9.4
32	7.0440	96.5	9.77	985	66.9	1.03	-12
33	6.9442	95.0	9.89	1,023	67.7	1.01	-13.4

* Optimal Harvesting Age

Table 16. Sensitivity of the Paper Company's Wood Growing Cost (When Funds Are Borrowed and Site Clearance Is Required) to Variations from the Optimal Harvesting Age for Site Index 60 at the Optimal Planting Density of 600 Trees per Acre

Harvesting Age (Years)	Paper Company's Wood Growing Cost Adjusted for Harvesting Cost (Dollars per Cord)	Percent of Minimum Wood Growing Cost	Tree D.B.H. (Inches)	Tree Weight (Pounds)	Tree Height (Feet)	Equivalent Harvesting Cost at Planting Time (Dollars per Cord)	Percentage Change in Harvesting Cost Relative to Cost at Optimal Age
20	12.21	1.12	6.95	363	52.9	2.21	+46
21	11.73	1.075	7.18	404	54.5	2.02	+34
22	11.36	1.04	7.40	446	56	1.85	+22
23	11.11	1.019	7.62	489	57.5	1.72	+14
24	10.96	1.002	7.83	532	58.7	1.60	+6
25*	10.91	1.00	8.03	575	60	1.51	0
26	10.96	1.002	8.21	617	61.1	1.42	-6
27	11.11	1.019	8.38	657	62.2	1.36	-10
28	11.35	1.04	8.53	696	63.2	1.30	-14
29	11.70	1.075	8.67	732	64.2	1.25	-17
30	12.17	1.12	8.79	766	65.1	1.21	-20

* Optimal Harvesting Age

Table 17. Sensitivity of the Independent Landowner's Rate of Return (Site Clearance Required) to Variations from the Optimal Harvesting Age for Site Index 80 at the Optimal Planting Density of 700 Trees per Acre

Harvesting Age (Years)	Rate of Return (Percent)	Percent of Maximum Rate of Return	Tree D.B.H. (Inches)	Tree Weight (Pounds)	Tree Height (Feet)	Equivalent Harvesting Cost at Planting Time (Dollars per Cord)	Percentage Change in Harvesting Cost Relative to Cost at Optimal Age
13	8.77	81.5	6.69	316	51	2.39	+90
14	9.49	88.0	6.98	376	54.1	2.04	+63
15	10.03	93.4	7.29	442	57.4	1.77	+41.5
16	10.43	97.0	7.60	516	60.5	1.55	+24
17	10.68	99.0	7.90	591	63.3	1.38	+10
18*	10.77	100.0	8.19	666	65.9	1.25	0
19	10.71	99.5	8.45	741	68.4	1.14	-8.6
20	10.58	98.2	8.68	813	70.6	1.06	-15
21	10.40	96.5	8.89	881	72.7	1.00	-20
22	10.19	94.5	9.06	945	74.7	.95	-24
23	9.96	92.5	9.21	1,003	76.6	.91	-27

* Optimal Harvesting Age

Table 18. Sensitivity of the Paper Company's Wood Growing Cost (When Funds are Borrowed and Site Clearance Is Required) to Variations from the Optimal Harvesting Age for Site Index 80 at the Optimal Planting Density of 600 Trees per Acre

Harvesting Age (Years)	Paper Company's Wood Growing Cost Adjusted for Harvesting Cost (Dollars per Cord)	Percent of Minimum Wood Growing Cost	Tree D.B.H. (Inches)	Tree Weight (Pounds)	Tree Height (Feet)	Equivalent Harvesting Cost at Planting Time (Dollars per Cord)	Percentage Change in Harvesting Cost Relative to Cost at Optimal Age
16	5.32	1.27	7.87	556	60.5	1.48	+59
17	4.81	1.15	8.21	641	63.3	1.31	+41
18	4.47	1.07	8.54	728	65.9	1.18	+27
19	4.29	1.025	8.85	818	68.4	1.07	+15
20	4.19	1.001	9.14	906	70.6	.99	+6
21*	4.18	1.00	9.40	992	72.7	.93	0
22	4.24	1.012	9.63	1,074	74.7	.88	-5.5
23	4.38	1.047	9.82	1,150	76.6	.84	-9.5
24	4.57	1.09	9.99	1,220	78.3	.81	-13
25	4.83	1.15	10.14	1,285	80.0	.78	-16
26	5.15	1.23	10.27	1,345	81.5	.76	-18

* Optimal Harvesting Age

Table 19. Sensitivity of the Independent Landowner's Rate of Return (Site Clearance Required) to Optimal Harvesting Ages at Planting Densities Other Than the Optimal Planting Density on Site Index 60

Planting Density (Trees per Acre)	Optimal Harvesting Age for Planting Density (Years)	Rate of Return (Percent)	Percent of Maximum Rate of Return	Tree D.B.H. (Inches)	Tree Weight (Pounds)	Tree Height (Feet)	Equivalent Harvesting Cost at Planting Time (Dollars per Cord)
200**							
300	31	7.066	97.0	11.48	1,361	66	.85
400	29	7.248	99.1	10.05	1,001	64	1.03
500*	28	7.296	100.0	9.12	802	63	1.17
600	26	7.295	99.9	8.12	617	61	1.42
700	25	7.222	99.0	7.60	511	60	1.60
800	25	7.137	98.0	7.20	459	60	1.79
900	24	6.951	95.4	6.76	384	58	2.06
1,000	24	6.769	92.8	6.47	347	58	2.24

* Optimal Planting Density
** Tree Characteristics Exceeded Harvester's Capacity

Table 20. Sensitivity of the Paper Company's Wood Growing Cost (When Funds Are Borrowed and Site Clearance Is Required) to Optimal Harvesting Ages at Planting Densities Other Than the Optimal Planting Density on Site Index 60

Planting Density (Trees per Acre)	Optimal Harvesting Age for Planting Density (Years)	Paper Company's Wood Growing Cost Adjusted for Harvesting Cost (Dollars per Cord)	Percent of Minimum Wood Growing Cost	Tree D.B.H. (Inches)	Tree Weight (Pounds)	Tree Height (Feet)	Equivalent Harvesting Cost at Planting Time (Dollars per Cord
200**							
300	30	12.18	1.12	11.15	1,265	65.2	.90
400	28	11.25	1.03	9.78	932	63.3	1.08
500	26	10.95	1.002	8.69	699	61.2	1.30
600*	25	10.91	1.00	8.03	576	60.0	1.51
700	24	11.10	1.015	7.45	477	58.8	1.70
800	23	11.35	1.04	6.98	402	57.5	1.99
900	22	11.91	1.09	6.53	336	56.1	2.30
1,000	22	12.42	1.14	6.27	306	56.1	2.48

* Optimal Planting Density
** Tree Characteristics Exceeded Harvester's Capacity

Table 21. Sensitivity of the Independent Landowner's Rate of Return (Site Clearance Required) to Optimal Harvesting Ages at Planting Densities Other Than the Optimal Planting Density on Site Index 80

Planting Density (Trees per Acre)	Optimal Harvesting Age for Planting Density (Years)	Rate of Return (Percent)	Percent of Maximum Rate of Return	Tree D.B.H. (Inches)	Tree Weight (Pounds)	Tree Height (Feet)	Equivalent Harvesting Cost at Planting Time (Dollars per Cord)
200**							
300**							
400	21	10.08	93.5	10.62	1,281	72	.80
500	19	10.38	96.5	9.28	905	68	1.01
600	18	10.62	99.0	8.54	728	66	1.17
700*	18	10.77	100.0	8.19	666	66	1.25
800	18	10.71	99.7	7.79	598	66	1.35
900	17	10.66	99.0	7.27	491	63	1.58
1,000	17	10.55	98.0	7.99	450	63	1.69

* Optimal Planting Density
** Tree Characteristics Exceeded Harvester's Capacity

Table 22. Sensitivity of the Paper Company's Wood Growing Cost (When Funds Are Borrowed and Site Clearance Is Required) to Optimal Harvesting Ages at Planting Densities Other Than the Optimal Planting Density on Site Index 80

Planting Density (Trees per Acre)	Optimal Harvesting Age for Planting Density (Years)	Paper Company's Wood Growing Cost Adjusted for Harvesting Cost (Dollars per Cord)	Percent of Minimum Wood Growing Cost	Tree D.B.H. (Inches)	Tree Weight (Pounds)	Tree Height (Feet)	Equivalent Harvesting Cost at Planting Time (Dollars per Cord)
200**							
300**							
400**							
500	22	4.21	1.01	10.26	1,225	75	.81
600*	21	4.18	1.00	9.40	992	73	.93
700	20	4.25	1.015	8.69	813	71	1.06
800	19	4.54	1.083	8.00	659	68	1.25
900	19	4.77	1.14	7.64	595	68	1.35
1,000	18	5.05	1.21	7.15	496	66	1.56

* Optimal Planting Density
** Tree Characteristics Exceeded Harvester's Capacity

can vary at least $\pm$ 100 trees per acre and maintain the rate of return and wood growing cost within 2 percent of the optimal values. The rate of return and wood growing cost change at an increasing rate as the planting densities vary from the optimal values. Since the planting density is readily controlled, it is recommended that the planting densities be at the optimal values. This is desirable because a combination of deviations from optimal planting density and harvesting age can lead to significant changes from optimal values of the rate of return and the wood growing cost. The maximum variance in harvesting age (without significant reduction in management objectives) is desirable so as to allow maximum response to demand and harvesting schedules.

CHAPTER XII

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Conclusions derived from the economic evaluation of forest planning and management alternatives, in conjunction with the proposed harvester design and management objectives of the independent landowner and the paper company, are summarized as follows:

(1) There are forest planning and management alternatives related to the proposed harvester design that provide a maximum rate of return on the forest investments and growing cost for the independent landowner and minimum wood growing cost for the paper company.

(2) The recommended forest planning and management alternatives that provide the maximum rate of return for the independent landowner (when site clearance is required) are initial planting densities (trees per acre) of: 400 harvested at 36 years for site index 50, 500 harvested at 28 years for site index 60, 600 harvested at 22 years for site index 70, and 700 harvested at 18 years for site index 80.

(3) The recommended forest planning and management alternatives that provide the maximum rate of return for the independent landowner (when site clearance is not required) are initial planting densities (trees per acre) of: 500 harvested at 32 years for site index 50, 600 harvested at 25 years for site index 60, 700 harvested at 21 years for site index 70, and 700 harvested at 18 years for site index 80.

(4) The recommended forest planning and management alternatives that provide the minimum wood growing cost (site clearance required) for the paper company (utilizing industrial funds for wood growing cost) are initial planting densities (trees per acre) of: 800 harvested at 19 years for site index 70, and 700 harvested at 18 years for site index 80.

(5) The recommended forest planning and management alternatives that provide the minimum wood growing cost (site clearance not required) for the paper company (utilizing industrial funds for wood growing cost) are initial planting densities (trees per acre) of: 700 harvested at 20 years for site index 70, and 700 harvested at 18 years for site index 80.

(6) When the paper company utilizes industrial funds (with normal expected annual profit of 9 percent after income tax) for wood growing cost, the paper company should not invest in forest land with a site index less than 70 (the paper company's wood growing cost on lower site indices is more than the current stumpage price at which wood can be purchased from the independent landowner).

(7) The recommended forest planning and management alternatives that provide the minimum wood growing cost (site clearance required) for the paper company (when wood growing cost is borrowed at 6 percent interest) are initial planting densities (trees per acre) of: 600 harvested at 25 years for site index 60, 600 harvested at 22 years for site index 70, and 600 harvested at 21 years for site index 80.

(8) When the paper company borrows funds (at 6 percent annual interest) for wood growing cost, the paper company should not invest in forest land with a site index less than 60 (the paper company's wood growing cost on lower site indices is more than the current stumpage price

at which wood can be purchased from the independent landowner).

(9) The maximum tree characteristics (related to the recommended optimal forest planning and management alternatives) for which the harvester design should be specialized and refined are: 9.73 inch D.B.H., 993 pounds tree weight, and 73 foot tree height.

(10) Negligible tree volume is lost if the harvester only harvests 50 feet of the tree (the maximum tree height at optimal forest planning and management alternatives is 73 feet which has an associated volume loss of 2.25 percent).

(11) The rate of return for the independent landowner and the wood growing cost for the paper company are significantly affected by the land site index.

(12) At the optimal forest planning and management alternatives, the independent landowner's rate of return is marginal for site index 50 (5.71 to 6.13 percent) and very good for site index 80 (10.78 to 11.5 percent).

(13) At the optimal forest planning and management alternatives, the paper company's wood growing cost is unacceptable for site index 40 (42.68 to 80.51 dollars per cord at harvesting time) and very good for site index 80 (8.14 to 8.60 dollars per cord at harvesting time).

(14) At the recommended optimal forest planning and management alternatives, the requirement of site clearance cost significantly reduces the independent landowner's rate of return (approximately 7 percent) and increases the paper company's wood growing cost (approximately 12 percent).

(15) The proposed harvester design, in conjunction with the recommended optimal forest planning and management alternatives,

significantly reduces the wood harvesting cost from the current harvesting cost (.93 to 1.50 dollars per cord as compared to 5.70 dollars per cord for the Buschcombine (20)).

(16) The proposed harvester design, in conjunction with recommended optimal forest planning and management alternatives, should provide adequate harvesting capacity since the associated man-machine production rate (17.5 to 32.2 cords per hour) is approximately tenfold greater than current production rates.

(17) In view of the resulting harvesting cost percentage (12.9 to 16.7 percent) of combined stumpage price (adjusted for harvesting cost) and harvesting cost allowance (for the independent landowner) as well as the resulting harvesting cost percentage (19.1 to 24.8 percent) of combined wood growing cost (adjusted for harvesting cost) and harvesting cost allowance (for the paper company), an additional iteration of harvester design refinement, in conjunction with forest planning and management policy, is recommended but the point of diminishing returns is soon to be reached with multiple iterations.

(18) Harvesting age can vary $\pm$ 1.5 years from the recommended optimal harvesting ages, so as to respond to harvesting schedules and demands, while resulting in less than a 2 percent change in the rate of return and the wood growing cost.

(19) The optimal planting densities should be closely adhered to so as to allow maximum variance in the harvesting age for response to harvesting schedules and demands without causing significant reductions in the rate of return and the wood growing cost.

(20) The recommended forest planning and management alternatives

that optimize the landowner's rate of return and the paper company's wood growing cost do not greatly reduce the forest yield from maximum yields (minimum of 94 percent of maximum land yield at all recommended alternatives).

The economical evaluation of forest planning and management alternatives, in conjunction with the proposed harvester design and management objectives, lead to the following general conclusions:

(1) Future pulpwood harvesting machine designs and future forest planning and management policies should be developed and refined in conjunction with each other and the management objectives.

(2) Current pulpwood harvesting equipment can be significantly improved through automation and efficient sequencing of operations.

(3) Computer simulation is a valuable tool in evaluating forest planning and management alternatives in conjunction with harvester designs and management objectives.

(4) The paper company can benefit by assisting the independent landowners in planning, managing, and harvesting his forest in order to help insure the landowner an adequate return on his investment.

(5) The independent landowner can benefit by cooperating with the paper company in planning, managing and harvesting his forest.

Recommendations

The following recommendations are offered relative to this work:

(1) The proposed harvester design should be redesigned for maximum tree characteristics of: 10 inch D.B.H., 1,000 pounds weight, and 65 foot height.

(2) When the economic model is rerun in later years, all cost values must be upgraded to the current planting time for which the model is being run and for local mill conditions at that time.

(3) The tree growth regression equations developed by Bennett, McGee, and Clutter (16) should be revised to account for tree growth to 35 years to allow for growth suppression.

(4) A forest growth model should be developed for improved future tree species so that the harvester design and forest planning and scientific management alternatives can be evaluated and refined for future tree species.

(5) Future harvesting machines and forest planning and management policies should be developed in conjunction with each other and with management objectives.

(6) There should be a high level of cooperation between the paper companies and the independent landowners in planning, planting, managing, and harvesting the forests.

(7) Due to the undesirable rate of return and wood growing cost associated with low site indices (which comprises a large percentage of available forest land), research should be conducted to determine economical means of upgrading land with low site indices.

APPENDIX I

HARVESTER OPERATING COST COMPUTATIONS

Harvester Cost

The total estimated harvester cost of 99,000 dollars is based on costs as listed below:

	Component	Unit Cost	Quantity	Total Cost
1.	Caterpillar, 944 Axle and Final Drive Assembly	$6,250	3	$18,750
2.	Vickers, 50M300, Vane Motor	700	3	2,100
3.	Tires, 17.5 X 25	950	6	5,700
4.	Caterpillar, D334, Diesel Engine	6,500	2	13,000
5.	Hydraulic Pumps	500	6	3,000
6.	Shear, Felling	3,000	1	3,000
7.	Shear, Bucking	3,000	3	9,000
8.	Hydraulic Cylinders, Lines, and Controls			12,000
9.	Frame			12,000
10.	Miscellaneous Equipment and Assembly			11,450
11.	Total Equipment and Assembly Cost			$90,000
12.	Profit			9,000
13.	Total Estimated Cost			$99,000

Harvester Operating Cost

The harvester operating cost of 30 dollars per hour is computed as below:

1.	Total Equipment Cost	$99,000.00
2.	Total Tire Cost	5,700.00
3.	Equipment Cost, Less Tires	$93,300.00
4.	Depreciation (Excluding Tire Cost) Based on 10,000 Hours	$ 9.33
5.	Interest, Insurance, and Taxes Based on 3¢ per Thousand Dollars of Total Equipment Cost	2.97
6.	Total Owning Cost (per Operating Hour)	$ 12.30
7.	Hourly Fuel Cost at 17.6 Gallon per Hour	2.64
8.	Hourly Hydraulic Oil Cost	.11
9.	Hourly Lubrication Cost	.40
10.	Hourly Repair Cost Based on 90 Percent of Depreciation	8.40
11.	Hourly Tire Cost Based on 4,500 Hours Tire Life	1.27
12.	Total Direct Operating Cost per Hour	$ 12.82
13.	Operator Hourly Wages and Related Expenses	4.88
	Total Harvester Operating Cost (per Hour)	$ 30.00

APPENDIX II

HARVESTER SIMULATION MODEL COMPUTER PROGRAM AND SAMPLE PRINTOUT

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LOC  NAME          X      Y      Z     SEL   NBA   NBB   MEAN  MOD   REMARKS    F

      JOB
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*              HARVESTER SIMULATION MODEL
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*                   PROGRAM VARIABLE SECTION
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 1    VARIABLE    FN2*FN3/K100
** V1 IS USED TO COMPUTE STANDARD TREE HEIGTH AS A FUNCTION OF DBH AND
****  A VARIANCE AROUND THAT HEIGHT
 2    VARIABLE    K160-X11
** V2 IS USED TO COMPUTE SHEAR SLUE DISTANCE PECULIAR TO THIN CUT
 3    VARIABLE    X9-X10+FN9
** V3 IS USED TO COMPUTE   BACK-UP DISTANCE IN FELLING OPERATION
 4    VARIABLE    X9-X10-K170
** V4 IS USED TO COMPUTE   FIRST ADVANCE DISTANCE IN FELLING OPERATION
 5    VARIABLE    X11-X5+K160
** V5 IS USED TO COMPUTE   SLUE DISTANCE TO TREE FOR SHEAR IN FELLING
****  OPERATION
 6    VARIABLE    K160-X11
** V6 IS USED TO COMPUTE SLUE DISTANCE TO TREE FOR GRAPPLE IN FELLING
****  OPERATION
 7    VARIABLE    P2-X50+K11
** V7 IS USED TO HELP DETERMINE IF THERE IS A NEED TO CHANGE POSITION
****  OF BUCKER REAR SHEAR
 8    VARIABLE    X102+X104-X101-X103
** V8 COMPUTES ACTUAL OPERATING TIME OF OPERATOR
 9    VARIABLE    X103-X102
** V9 COMPUTES TIME OPERATOR WAITS ON SHEAR AVAILABILITY
 10   VARIABLE    Q1+Q11+Q12
** V10 IS USED IN CONTROLLING THE RATE THAT TREE TRANSACTIONS ARE
****  GENERATED
 11   VARIABLE    X104-X101
** V11 COMPUTES TIME TREE IS IN CONTROL OF OPERATOR
 12   VARIABLE    X113+X116+X120+X123-X112-X114-X117-X122
** V12 COMPUTES ACTUAL OPERATING TIME OF SHEAR
 13   VARIABLE    X112+X114+X117+X122-X111-X113-X116-X120
** V13 COMPUTES TIME SHEAR WAITS ON AVAILABILITY OF OPERATOR AND GRAPPLE
 14   VARIABLE    X10-K42
** V14 IS USED TO COMPUTE Y LOCATION WHERE TOPS OF TREES GREATER THAN
****  80 FT. ARE DROPPED
 15   VARIABLE    X10-K25
** V15 IS USED TO COMPUTE Y LOCATION WHERE TOPS OF TREES 65 TO 80 FT.
****  ARE DROPPED
 16   VARIABLE    X123-X111
** V16 COMPUTES TIME TREE IS IN CONTROL OF SHEAR
 17   VARIABLE    X133+X136+X140+X143-X132-X134-X137-X142
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** V17 COMPUTES ACTUAL OPERATING TIME OF GRAPPLE
 18   VARIABLE    X132+X134+X137+X142-X131-X133-X136-X140
** V18 COMPUTES TIME GRAPPLE WAITS ON AVAILABILITY OF SHEAR AND
****  DELIMBER
 19   VARIABLE    X143-X131
** V19 COMPUTES TIME TREE IS IN CONTROL OF GRAPPLE
 20   VARIABLE    X153+X156-X152-X154
** V20 COMPUTES ACTUAL OPERATING TIME OF DELIMBER
 21   VARIABLE    X152+X154-X151-X153
** V21 COMPUTES TIME DELIMBER WAITS ON AVAILABILITY OF GRAPPLE AND
****  BUCKER
 22   VARIABLE    X156-X151
** V22 COMPUTES TIME TREE IS IN CONTROL OF DELIMBER
 23   VARIABLE    X162+X164+X167-X161-X163-X166
** V23 COMPUTES ACTUAL OPERATING TIME OF BUCKER
 24   VARIABLE    X163+X166-X162-X164
** V24 COMPUTES TIME BUCKER WAITS ON AVAILABILITY OF DELIMBER AND
****  CONVEYER
 25   VARIABLE    X167-X161
** V25 COMPUTES TIME TREE IS IN CONTROL OF BUCKER
 26   VARIABLE    X172-X171
** V26 COMPUTES TIME TREE IS IN CONTROL OF CONVEYER
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*                       PROGRAM FUNCTION SECTION
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 1    FUNCTION     RN1    C5
.0    50    .20    58    .50    60    .80    62    1     70
** FN1 IS USED TO ASSIGN A DBH TO TREE TRANSACTIONS
 2    FUNCTION     P1     C5
50    40    55     48    60     54    65     59    70    63
** FN2 IS USED TO DETERMINE THE STANDARD HEIGTH AS A FUNCTION OF DBH
 3    FUNCTION     RN1    C5
.0    80    .20    95    .50    100   .80    105   1     120
** FN3 IS USED TO DETERMINE THE DEVIATION FROM THE STANDARD HEIGTH
 4    FUNCTION     RN1    D2
.0    85    1      86
** FN4 IS USED TO ASSIGN A Y LOCATION TO THE TREE TRANSACTION FOR
****  600 TREES PER ACRE
 5    FUNCTION     RN1    C5
.0    70    .20    78    .50    80    .80    82    1     90
** FN5 IS USED TO ASSIGN A X LOCATION TO THE TREE TRANSACTIONS
 6    FUNCTION     P3     D44
2     10    3      3     5      10    6      5     14    10    16    3
17    10    18     3     25     10    26     3     34    10    35    3
38    10    39     5     40     3     41     10    42    3     46    10
47    3     50     10    51     3     53     10    54    3     55    10
56    5     63     10    64     5     65     10    66    3     70    10
71    3     76     10    77     3     84     10    85    3     86    10
88    3     89     5     92     10    94     3     96    10    97    3
120   10    121    75
** FN6 IS USED TO ASSIGN TREE TRANSACTIONS A GRADE (FATALITY=3,
****  DEFECTIVE TREE=5, AND HARVESTABLE TREE=10) FOR 75 PERCENT
****  SURVIVAL (HARVESTABLE TREES)
 7    FUNCTION     RN1    C5
.0    26    .20    29    .50    30    .80    31    1     34
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** FN7 HELPS ASSIGN TERRAIN CLASSIFICATION TO TREE TRANSACTIONS
 8    FUNCTION     P8     C5
15    1     25     2     35     3     45     4     60     5
** FN8 IS USED TO ASSIGN TERRAIN CLASSIFICATION TO TREE TRANSACTIONS
 9    FUNCTION     X5     C17
0     28    10     20    20     15    30     10    40     6     50     3
60    1     70     0     80     0     90     0     100    1     110    3
120   6     130    10    140    15    150    20    160    28
** FN9 IS USED TO COMPUTE A Y CORRECTION AS A FUNCTION OF X FOR
****  DETERMINING BACK-UP AND ADVANCE DISTANCES
 10   FUNCTION     X8     D2
6     146   12     140
** FN10 IS A ROUTING CONTROL AS A FUNCTION OF THE TYPE CUT (THIN OR
****  CLEAR)
 11   FUNCTION     X15    C3
0     80    80     0     160    80
** FN11 IS USED TO CONVERT TREE LOCATION TO SHEAR   SLUE DISTANCE
 12   FUNCTION     P7     C2
0     0     160    80
** FN12 IS USED TO DETERMINE SLUE TIME FOR SHEAR
 13   FUNCTION     P6     C3
100   70    170    0     30000 0
** FN13 IS USED TO DETERMINE BACK-UP DISTANCE
 14   FUNCTION     P5     C2
0     0     200    100
** FN14 IS USED TO DETERMINE BACK-UP TIME
 15   FUNCTION     P4     C2
0     0     500    250
** FN15 IS USED TO DETERMINE FIRST ADVANCE TIME
 16   FUNCTION     P8     D2
6     95    12     92
** FN16 IS A ROUTING CONTROL AS A FUNCTION OF THE TYPE CUT (THIN OR
****  CLEAR)
 17   FUNCTION     X1     C4
0     20    40     20    90     45    120    70
** FN17 IS USED TO DETERMINE SHEARING TIME FOR DEFECTIVE TREES
 18   FUNCTION     P6     D2
6     85    12     77
** FN18 IS A ROUTING CONTROL FOR SPLITTING BLOCKS AS A FUNCTION OF THE
****  GRADE OF TREE (DEFECTIVE OR HARVESTABLE)
 19   FUNCTION     P6     D2
6     91    12     89
** FN19 IS A ROUTING CONTROL FOR THE OPERATOR AS A FUNCTION OF THE
****  GRADE OF TREE (DEFECTIVE OR HARVESTABLE)
 20   FUNCTION     X6     D2
6     38    12     39
** FN20 IS A ROUTING CONTROL FOR THE SHEAR  TERRAIN SET AS A FUNCTION
****  OF THE GRADE OF TREE (DEFECTIVE OR HARVESTABLE)
 22   FUNCTION     X6     D2
6     174   12     200
** FN22 IS A ROUTING CONTROL FOR THE SHEAR AS A FUNCTION OF THE
****  GRADE OF TREE (DEFECTIVE OR HARVESTABLE)
 23   FUNCTION     X1     C4
0     12    40     12    90     31    120    46
** FN23 IS USED TO COMPUTE PHASE 1 SHEAR TIME
 24   FUNCTION     X1     C4
0     8     40     8     90     14    120    24
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** FN24 IS USED TO COMPUTE PHASE 2 SHEAR TIME
 25   FUNCTION     X5     D3
60     169   110   196   160   169
** FN25 IS A ROUTING CONTROL FOR DELAYING SHEAR IF NEXT TREE IS IN A
**** ZONE THAT WILL CAUSE INTERFERENCE WITH GRAPPLE AS MACHINE ADVANCES
**** THE SHEAR
 26   FUNCTION     X21    C2
0      10    160   4
** FN26 IS USED TO COMPUTE GRAPPLE CLOSING TIME (PARTIAL)
 27   FUNCTION     P5     C2
0      0     80    40
** FN27 IS USED TO COMPUTE SLUE TIME FOR EMPTY GRAPPLE
 28   FUNCTION     X21    C4
0      20    90    15    120   10    160   5
** FN28 IS USED TO COMPUTE GRAPPLE CLOSING TIME ON TREE
 29   FUNCTION     X27    D5
1      10    2     9     3     8     4     7     5     6
** FN29 IS USED TO COMPUTE FINIAL ROTATION TIME OF GRAPPLE AS A
**** FUNCTION  OF TERRAIN
 30   FUNCTION     X27    D5
1      4     2     3     3     2     4     1     5     0
** FN30 IS USED TO COMPUTE TIME TO ROTATE TREE AND GRAPPLE TO SLUE
**** POSITION AS A FUNCTION OF TERRAIN
 31   FUNCTION     P5     C2
0      0     80    40
** FN31 IS USED TO COMPUTE SLUE TIME OF GRAPPLE WITH TREE
 32   FUNCTION     X42    D3
65     0     80    10    115   0
** FN32 IS USED IN ESTABLISHING CONTROL FOR BUCKER SHEAR AND ROUTING
 33   FUNCTION     X51    D3
8      10    14    0     22    10
** FN33 IS USED TO ASSIGN CONTROL FOR BUCKER SHEAR AND ROUTING
 34   FUNCTION     P3     D2
5      356   15    359
** FN34 ROUTES TRANSACTIONS FROM BLOCK 409 TO BLOCK 356 TO SIMULATE
****   RETURN OF BUCKER FLIP IF THERE IS NO CHANGE IN BUCKER REQUIRED OR
****   TO BLOCK 359 TO SIMULATE RETURN AND POSITIONING OF BUCKER FLIP
****   IF THERE IS A CHANGE REQUIRED IN BUCKER SETTING TO PROCESS THIS
****   TREE
 35   FUNCTION     P2     D2
5      358   15    357
** FN35 ROUTES TRANSACTIONS FROM BLOCK 356 TO BLOCK 357 TO RETURN BUCKER
****   RECEIVING FLIP IF THE TREES CURRENTLY BEING PROCESSED ARE 65 TO
****   80 FT LONG OR TO BLOCK 358 TO RETURN BUCKER DISCHARGING FLIP IF
****   TREES THAT ARE BEING CURRENTLY PROCESSED ARE NOT 65 TO 80 FT LONG
 36   FUNCTION     P2     D2
5      362   15    360
** FN36 ROUTES TRANSACTIONS FROM BLOCK 359 TO BLOCK 360 TO RETURN BUCKER
****   DISCHARGING FLIP AND ROTATE DISCHARGE FLIP ASSEMBLY DOWN IF TREE
****   IS 65 TO 80 FT. OR TO BLOCK 362 TO ROTATE A DISCHARGING FLIP
****   ASSEMBLY UP IF THE CURRENT TREE IS NOT 65 TO 80 FT. LONG
 37   FUNCTION     P3     C2
5      365   15    363
** FN37 ROUTES TRANSACTIONS FROM BLOCK 410 TO BLOCK 365 TO WAIT AT
****   BLOCK 363 IF THERE IS A CHANGE NEEDED IN REAR SHEAR POSITION FOR
****   CURRENT TREE
 38   FUNCTION     X41    C5
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0      10    60    20    100   40    140   70    160   100
** FN38 COMPUTES BUCKER SHEARING TIME
 39    FUNCTION    P2    D2
5      379   15    381
** FN39 ROUTES TRANSACTIONS FROM BLOCK 411 TO BLOCK 379 IF CURRENT
****   BUCKER TREE IS NOT 65 TO 80 FT. LONG TO SIMULATE FLIPPING REAR
****   BOLTS OUT OF BUCKER TO CONVEYER OR TO BLOCK 381 IF CURRENT BUCKER
****   TREE IS 65 TO 80 FT. LONG TO SIMULATE UPPER BOLT AND TOP BEING
****   FLIPPED OUT OF BUCKER TO THE GROUND
 40    FUNCTION    X16   C3
0      80    80    0     160   80
** FN40 COMPUTES GRAPPLE SLUE DISTANCE TO TREE
 41    FUNCTION    P2    D2
65     574   115   575
** FN41 ROUTES TRANSACTIONS FROM BLOCK 573 TO BLOCK 574 TO TERMINATE
****   IF LENGTH LESS THAN 65 FT. OR TO BLOCK 575 OTHERWISE
 42    FUNCTION    X61   C2
0      0     200   100
 43    FUNCTION    X62   C2
0      0     30000 7000
 44    FUNCTION    X42   D2
80     373   115   407
** FN44  ROUTES TRANSACTIONS FROM BLOCK 406 TO BLOCK 407 IF TREE IS
****   LONGER THAN 80 FT. TO RECORD THE X AND Y POSITION OF THE TOPS AS
****   THEY ARE DROPPED TO THE GROUND FROM THE BUCKER OR TO BLOCK 373 IF
****   TREE IS LESS THAN 80 FT, LONG TO AVOID BLOCK 407
 45    FUNCTION    X42   C3
65     382   80    385   115   382
** FN45 ROUTES TRANSACTIONS FROM BLOCK 384 TO BLOCK 385 IF CURRENT
****   BUCKER TREE IS 65 TO 80 FT. TO RECORD X AND Y POSITION OF TREE
****   TOP WHEN IT IS FLIPPED OUT OF BUCKER ONTO THE GROUND OR TO BLOCK
****   382 IF TREE IS LESS THAN 65 FT. LONG TO RELEASE THE ASSEMBLE
****   BLOCK
 46    FUNCTION    P6    D2
7      13    12    9
** FUNCTION 46 HELPS BLOCK 12 ROUTE TREES RELATIVE TO HARVESTABLE OR
****   DEFECTIVE TREES. IF DEFECTIVE (P6=5), THE TREE TRANSACTION IS
****   ROUTED TO BLOCK 13. IF HARVESTABLE (P=10), THE TREE TRANSACTION
****   IS ROUTED TO BLOCK 9.
 47    FUNCTION    P6    D2
4      31    15    21
** FN47 IS A ROUTING CONTROL AS A FUNTION OF GRADE OF TREE (IF NO-CUT
****   FATALITY  (P6<4), IT IS ROUTED TO BLOCK 31. IF HARVESTABLE OR
****   DEFECTIVE TREE REQUIRING CUTTING (P6>4), IT IS ROUTED TO BLOCK 31)
 48    FUNCTION    P6    D2
4      111   15    36
** FN48 IS A ROUTING CONTROL AS A FUNCTION OF GRADE OF TREE (IF NO-CUT
****   FATALITY (P6<4), IT IS ROUTED TO BLOCK 111. IF HARVESTABLE OR
****   DEFECTIVE TREE REQUIRING CUTTING (P6>4), IT IS ROUTED TO BLOCK 36)
 57    FUNCTION    X15   C3
0      160   160   0     320   160
** FN57 COMPUTES SLUE TO TREE DISTANCE FOR SHEAR
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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*                   SUBPROGRAM FOR FOREST GENERATOR AND MODEL CONTROL
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 1     GENERATE             106    4            2           10
** BLOCK 1 CREATES TREE TRANSACTIONS
 2     COMPARE        V10    LE     K1          3
** BLOCK 2 CONTROLS THE RATE THAT TREE TRANSACTIONS ARE CREATED
 3     ASSIGN         1      K50                4
** BLOCK 3 ASSIGNS A DBH IN TENS OF INCHES TO EACH TREE TRANSACTION
 4     ASSIGN         2      K60                540
** BLOCK 4 ASSIGNS A HEIGHT IN FEET TO EACH TREE TRANSACTION
 540   SAVEX          181+   K1                 5
** BLOCK 540 HELPS BLOCK 5 ASSIGN TREE NUMBER
 5     ASSIGN         3      X181               6
** BLOCK 5 ASSIGNS THE TREE NUMBER
 6     ASSIGN         4      FN4                7
** BLOCK 6 ASSIGNS Y LOCATION TO THE TREE TRANSACTION IN TENS OF FEET
 7     ASSIGN         5      FN5                8
** BLOCK 7 ASSIGNS X LOCATION TO THE TREE TRANSACTION IN TENS OF FEET
 8     ASSIGN         6      FN6                9
** BLOCK 8 ASSIGNS A GRADE TO THE TREE TRANSACTION (FATALITY=3,
****  DEFECTIVE TREE=5, AND HARVESTABLE TREE=10)
 9     ASSIGN         8      FN7                10
** BLOCK 9 HELPS BLOCK 10 IN ASSIGNING TERRAIN CLASSIFICATION TO EACH
****  TREE TRANSACTION
 10    ASSIGN         7      FN8                11
** BLOCK 10 ASSIGNS TERRAIN CLASSIFICON TO EACH TREE TRANSACTION
 11    ASSIGN         8      K5                 50
** BLOCK 11 ASSIGNS TYPE CUT TO EACH TREE TRANSACTION (5=CLEAR, 10=THIN)
 50    QUEUE          1      K1                 70
** BLOCK 50 QUEUE FOR TREES AWAITING PROCESSING
 51    GENERATE              1                  52
** BLOCK 51 GENERATES A TRANSACTION TO SET SAVEXS TO INITIAL VALUES
 52    SAVEX          9      K630               53
** BLOCK 52 SETS SAVEX 9 TO 630 WHICH IS Y LOCATION OF THE FIRST
****  TREE THAT IS TO BE PROCESSED THROUGH THE SIMULATION
 53    SAVEX          10     K500               54
** BLOCK 53 SETS SAVEX 10 TO 500 WHICH IS THE Y LOCATION OF THE MACHINE
**** AT THE BEGINNING OF THE SIMULATION
 54    SAVEX          11     K80                55
** BLOCK 54 SETS SAVEX 11 TO 80 WHICH IS THE X LOCATION OF THE SHEAR AT
**** THE BEGINNING OF THE SIMULATION
 55    SAVEX          20     K5                 56
** BLOCK 55 SETS SAVEX 20 TO 5 WHICH SETS A CONTROL THAT HOLDS THE
**** GRAPPLE UNTIL THE SHEAR HAS SLUED TO THE TREE
 56    SAVEX          30     K10                57
** BLOCK 56 SETS SAVEX 30 TO 10 WHICH SETS A CONTROL THAT HOLDS THE
**** FINAL ADVANCE OF THE SHEAR IF NEXT TREE FOR SHEAR IS IN A ZONE
**** THAT WILL INTERFERE WITH GRAPPLE MOVEMENT WITH CURRENT TREE
 57    SAVEX          35     K10                58
** BLOCK 57 SETS SAVEX 35 TO 10 WHICH SETS A CONTROL THAT HOLDS THE
**** GRAPPLE DURING CERTAIN PHASES OF THE DELIMBER OPERATION
 58    SAVEX          50     K0                 60
** BLOCK 58   SETS SAVEX 50 TO 0 WHICH SETS A CONTROL THAT ROUTES
**** TREE TRANSACTION THROUGH THE BUCKER AND SETS THE BUCKER SHEAR
 60    SAVEX          60     K0                 61
** BLOCK 60 SETS SAVEX 60 TO 0 WHICH IS THE Y LOCATION OF THE MACHINE
**** AT THE BEGINNING OF THE TOP HARVESTING OPERATION
 61    SAVEX          70     K10                72
** BLOCK 61 SETS SAVEX 70 TO 10 WHICH SETS A CONTROL THAT HOLDS THE
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**** GRAPPLE DURING CERTAIN PHASES OF THE DELIMBER OPERATION DURING
**** HARVESTING OF TOPS
 72   TERMINATE
** BLOCK 72 TERMINATES THE INITIAL SAVEX SETTING TRANSACTION
 70   QUEUE          11    K1                  74
** BLOCK 70 QUEUE FOR TREE TRANSACTIONS AWAITING INITIAL SETTING OF
****  SAVEXS
 74   COMPARE       N72    GE    K1            71
** BLOCK 74 CONTROL TO HOLD TREE PROCESSING UNTIL SAVEXS HAVE BEEN SET
 71   QUEUE          12    K1                  75
** BLOCK 71 QUEUE FOR TREE TRANSACTIONS AWAITING AVAILIBILITY OF
****  OPERATOR
 75   GATE          NU1                        76
** BLOCK 75 CONTROLS FLOW OF TREE TRANSACTIONS RELATIVE TO AVAILABILITY
**** OF OPERATOR
 76   SPLIT                                    80     129
** BLOCK 76 CREATES A DUPLICATE TREE TRANSACTION FOR THE SHEAR
 77   SPLIT                                    78     225
** BLOCK 77 CREATES A DUPLICATE TREE TRANSACTION FOR THE GRAPPLE
 78   SPLIT                                    79     300
** BLOCK 78 CREATES A DUPLICATE TREE TRANSACTION FOR THE DELIMBER
 79   SPLIT                                    85     340
** BLOCK 79 CREATES A DUPLICATE TREE TRANSACTION FOR THE BUCKER
 80   ADVANCE                            FN    18
** BLOCK 80 ROUTES TRANSACTIONS RELATIVE TO GRADE (IF DEFECTIVE, IT IS
***  ROUTED TO BLOCK 85. IF HARVESTABLE, IT IS ROUTED TO BLOCK 77)
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*                   SUBPROGRAM FOR OPERATOR SIMULATION
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 85   SEIZE          1                         545
** BLOCK 85 SEIZES FACILITY 1 WHICH IS THE OPERATOR
 545  SAVEX          106   K1                  20
** BLOCK 545 ASSIGNS SAVEX 106 A VALUE OF 1 TO IDENTIFY FATALITIES
****  IN THE PRINTOUT
 20   SAVEX          100   P3            FN    47
** BLOCK 20 (SAVEX 100) RECORDS THE NUMBER OF THE TREE AT THE OPERATOR
****  AND ROUTING IS DETERMINED RELATIVE TO TREE GRADE (IF NO-CUT
****  FATALITY (P6<4), IT IS ROUTED TO  BLOCK 31. IF HARVESTABLE TREE OR
****  DEFECTIVE TREE REQUIRING CUTTING (P6>4), IT IS ROUTED TO BLOCK 21)
 21   SAVEX          101   C1                  86
** BLOCK 21 (SAVEX 101) RECORDS TIME WHEN TREE IS AT BLOCK 21
 86   HOLD           2                         87             15
** BLOCK 86 TIME REQUIRED FOR OPERATOR TO SELECT NEXT TREE
 87   HOLD           3                         88             10
** BLOCK 87 TIME REQUIRED FOR OPERATOR TO ESTIMATE DBH
 88   HOLD           4                   FN    19             10
** BLOCK 88 TIME REQUIRED FOR OPERATOR TO GRADE TREE AND ROUTING IS
**** DETERMINED RELATIVE TO GRADE (IF DEFECTIVE (P6=5), IT IS ROUTED TO
****  BLOCK 91. IF HARVESTABLE (P6=10), IT IS ROUTED TO BLOCK 89)
 89   SAVEX          106   K0                  22
** BLOCK 89 IDENTIFIES HARVESTABLE TREES IN PRINTOUT
 22   HOLD           5                         23             10
** BLOCK 22 IS TIME REQUIRED FOR DETERMINING TERRAIN CLASSIFICATION
****  OF THE TREE
 91   SAVEX          106   K1111               23
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** BLOCK 91 IDENTIFIES IN PRINTOUT DEFECTIVE TREES THAT MUST BE CUT
 23    SAVEX          102    C1                       24
** BLOCK 23 (SAVEX 102) RECORDS TIME WHEN TREE IS AT BLOCK 23
 24    HOLD           7                    FN         16
** BLOCK 24 ROUTES TREE TRANSACTIONS RELATIVE TO TYPE OF CUT (IF CLEAR-5
**** IT IS ROUTED TO BLOCK 95 OR IF THIN CUT-10 IT IS ROUTED TO
****  BLOCK 92)
 92    MATCH          142                             93
** BLOCK 92 HOLDS THE OPERATOR FOR SHEAR AVAILABILITY BEFORE THE
****  OPERATOR PREPARES TO SLUE
 93    HOLD           8                               94          10
** BLOCK 93 IS TIME REQUIRED FOR OPERATOR TO DETERMINE SLUE REQUIREMENT
****  AND PREPARATION FOR SLUE
 94    MATCH          143                             95
** BLOCK 94 HOLDS SHEAR BEFORE SLUE UNTIL OPERATOR IS PREPARED TO SLUE
****  TO NEUTRAL POSITION
 95    MATCH          146                             25
** BLOCK 95 HOLDS OPERATOR UNTIL SLUE IS COMPLETED IF THINNING OPERATION
**** IS BEING CONDUCTED OR IN CLEAR CUTTING OPERATION THIS BLOCK HOLDS
****  THE OPERATOR UNTIL  THE SHEAR IS AVAILABLE
 25    SAVEX          103    C1                       96
** BLOCK 25 (SAVEX 103) RECORDS TIME WHEN TREE IS AT BLOCK 25
 96    HOLD           9                               97          10
** BLOCK 96 IS THE TIME REQUIRED FOR THE OPERATOR TO DETERMINE
**** THE BACK-UP REQUIREMENT AND PREPARE TO BACK-UP
 97    MATCH          153                             98
** BLOCK 97 HOLDS THE SHEAR UNTIL THE OPERATOR IS PREPARED TO BACK-UP
 98    MATCH          156                             99
** BLOCK 98 HOLDS THE OPERATOR FOR THE SHEAR AND MACHINE TO BACK-UP
 99    HOLD           10                              100         10
** BLOCK 99 IS THE TIME REQUIRED FOR THE OPERATOR TO DETERMINE
**** THE ADVANCE 1 REQUIREMENT AND PREPARE FOR ADVANCE 1
 100   MATCH          157                             101
** BLOCK 100 HOLDS THE SHEAR AND MACHINE FOR THE OPERATOR TO PREPARE
****  FOR ADVANCE 1
 101   MATCH          161                             102
** BLOCK 101 HOLDS THE OPERATOR FOR THE SHEAR AND MACHINE TO COMPLETE
****  ADVANCE 1
 102   HOLD           11                              103         10
** BLOCK 102 IS THE TIME REQUIREMENT FOR THE OPERATOR TO DETERMINE THE
**** SHEAR SLUE TO TREE REQUIREMENT AND PREPARATION FOR IT
 103   MATCH          162                             104
** BLOCK 103 HOLDS SHEAR AND MACHINE FOR OPERATOR TO PREPARE FOR
****  SLUE TO TREE
 104   MATCH          167                             105
** BLOCK 104 HOLDS OPERATOR FOR SHEAR TO COMPLETE SLUE TO TREE
 105   HOLD           12                              106         10
** BLOCK 105 IS THE TIME REQUIREMENT FOR THE OPERATOR TO DETERMINE THE
**** ADVANCE 2 REQUIREMENT AND PREPARE FOR IT
 106   MATCH          168                             107
** BLOCK 106 HOLDS THE SHEAR FOR THE OPERATOR TO PREPARE FOR ADVANCE 2
 107   MATCH          172                             26
** BLOCK 107 HOLDS OPERATOR FOR THE MACHINE TO COMPLETE ADVANCE 2
 26    SAVEX          104    C1                       27
** BLOCK 26 (SAVEX 104) RECORDS TIME WHEN TREE IS AT BLOCK 26
 27    SAVEX          105    V8                       28
** BLOCK 27 (SAVEX 105) RECORDS ACTUAL OPERATING TIME OF OPERATOR
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 28   SAVEX        108   V9                    29
** BLOCK 28 (SAVEX 108) RECORDS TIME OPERATOR WAITS ON SHEAR AVAILABILITY
 29   SAVEX        109   V11                   30
** BLOCK 29 (SAVEX 109) RECORDS TIME TREE IS IN CONTROL OF OPERATOR
 30   PRINT        100   109                   108
** BLOCK 30 PRINTS PROCESS TIMES OF OPERATOR
 108  RELEASE      1                           109
** BLOCK 108 RELEASES FACILITY 1 WHICH IS THE OPERATOR
 109  TERMINATE
** BLOCK 109 TERMINATES THE TRANSACTION AS IT IS RELEASED FROM FACILITY
****  1
 31   SAVEX        101   C1                    32
** BLOCK 31 (SAVEX 101) RECORDS TIME WHEN TREE IS AT BLOCK 31
 32   SAVEX        102   C1                    33
** BLOCK 32 (SAVEX 102) RECORDS TIME WHEN TREE IS AT BLOCK 32
 33   SAVEX        103   C1                    34
** BLOCK 33 (SAVEX 103) RECORDS TIME WHEN TREE IS AT BLOCK 33
 34   SAVEX        104   C1                    27
** BLOCK 34 (SAVEX 104) RECORDS TIME WHEN TREE IS AT BLOCK 34
 129  QUEUE        2     K1                    130
** BLOCK 129 QUEUE FOR THREE TRANSACTION AWAITING PROCESSING
****  THROUGH THE SHEAR
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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*                SUBPROGRAM FOR SHEAR SIMULATION
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 130  SEIZE        20                          128
** BLOCK 130 SEIZES FACILITY 20 WHICH IS THE SHEAR
 128  SPLIT                                    209   131
** BLOCK 128 FORMS A DUPLICATE TREE TRANSACTION TO PROCESS THROUGH
**** THE SHEAR WHILE HOLDING THE ORIGINAL TRANSATION TO RELEASE FACILITY
**** 20 AS A REQUIREMENT OF PROGRAMMING PROCEDURE
 131  SAVEX        1     P1                    132
** BLOCK 131 ASSIGNS SAVEX 1 THE DBH VALUE OF THE CURRENT TRANSACTION
****  IN THE SHEAR
 132  SAVEX        2     P2                    133
** BLOCK 132 ASSIGNS SAVEX 2 THE HEIGHT VALUE OF THE CURRENT TRANSACTION
****  IN THE SHEAR
 133  SAVEX        3     P3                    134
** BLOCK 133 ASSIGNS SAVEX 3 THE TREE NUMBER OF THE CURRENT
****  TRANSACTION IN THE SHEAR
 134  SAVEX        4     P4                    135
** BLOCK 134 ASSIGNS SAVEX 4 THE Y LOCATION OF THE CURRENT TRANSACTION
****  IN THE SHEAR
 135  SAVEX        5     P5                    136
** BLOCK 135 ASSIGNS SAVEX 5 THE X LOCATION OF THE CURRENT TRANSACTION
****  IN THE SHEAR
 136  SAVEX        6     P6                    137
** BLOCK 136 ASSIGNS SAVEX 6 THE TREE GRADE (DEFECTIVE OR HARVESTABLE)
****  OF THE CURRENT TRANSACTION IN THE SHEAR
 137  SAVEX        7     P7                    138
** BLOCK 137 ASSIGNS SAVEX 7 THE TERRAIN CLASSIFICATION FOR THE CURRENT
****  TRANSACTION IN THE SHEAR
 138  SAVEX        8     P8                    139
** BLOCK 138 ASSIGNS SAVEX 8 THE TYPE CUT FOR THE CURRENT TRANSACTION
****  IN THE SHEAR
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 139  SAVEX        9+     P4                  35
** BLOCK 139 RECORDS ABSOLUTE LOCATION OF NEW TREE
 35   SAVEX        110    P3          FN      48
** BLOCK 35 (SAVEX 110) RECORDS THE NUMBER OF THE TREE AT THE SHEAR
****  AND ROUTING IS DETERMINED RELATIVE TO TREE GRADE (IF NO-CUT
****  FATALITY (P6<4), IT IS ROUTED TO BLOCK 111. IF HARVESTABLE TREE OR
****  DEFECTIVE TREE REQUIRING CUTTING (P6>4), IT IS ROUTED TO BLOCK 36)
 36   SAVEX        111    C1          FN      10
** BLOCK 36 ( SAVEX 111) RECORDS TIME WHEN TREE IS AT BLOCK 36
****  AND ROUTES TREES RELATIVE TO TYPE OF CUT (IF X8=5, BLOCK 146,
****  CLEAR CUT OR IF X8=10, BLOCK 140, THIN CUT)
 140  SAVEX        15     V2                  141
** BLOCK 140 RECORDS THE POSITION OF THE SHEAR FROM THE LAST TREE
****  RELATIVE TO 160 POSITION AND ASSIGNS VALUE TO SAVEX 15
 141  ASSIGN       7      FN11                142
** BLOCK 141 COMPUTES SLUE DISTANCE TO 80 POSITION AS A FUNCTION OF
****  SAVEX 15 AND ASSIGNS VALUE TO PARAMETER 7
 142  MATCH        92                         143
** BLOCK 142 HOLDS SHEAR FOR THE AVAILABILITY OF THE OPERATOR TO
****  PREPARE TO SLUE TO 80 POSITION
 143  MATCH        94                         144
** BLOCK 143 HOLDS SHEAR FOR OPERATOR TO PREPARE FOR SLUE TO 80 POSITION
 144  HOLD         21                         145        1      FN12
** BLOCK 144 SLUE TIME FOR SHEAR TO SLUE TO 80 POSITION
 145  SAVEX        11     K80                 146
** BLOCK 145 SETS RECORD OF SHEAR POSITION TO 80
 146  MATCH        95                         37
** BLOCK 146 HOLDS OPERATOR UNTIL SLUE IS COMPLETED IF THINNING
**** OPERATION IS BEING CONDUCTED, IN CLEAR CUTTING OPERATION THIS BLOCK
**** HOLDS THE OPERATOR UNTIL THE SHEAR IS AVAILABLE
 37   SAVEX        112    C1                  147
** BLOCK 37 (SAVEX 112) RECORDS TIME TREE IS AT BLOCK 37
 147  SPLIT                                   148   149
** BLOCK 147 FORMS A DUPLICATE TRANSACTION FOR SHEAR OPENING TIME
 148  SPLIT                                   151   197
** BLOCK 148 FORMS A DUPLICATE TRANSACTION FOR SHEAR TERRAIN SET IF TREE
****  GRADE IS HARVESTABLE
 149  HOLD         22                         166        20
** BLOCK 149 IS SHEAR OPENING TIME
 197  ADVANCE                     FN     20
** BLOCK 197 ROUTES TRANSACTION AS A FUNCTION OF TREE GRADE (IF
****  DEFECTIVE TREE (P6=5), ROUTE TO BLOCK 38 OR IF HARVESTABLE
****  (P6=10), ROUTE TO BLOCK 39 FOR SHEAR TERRAIN SET)
 38   SAVEX        121    K1111               166
** BLOCK 38 (SAVEX 121) IDENTIFIES IN PRINTOUT DEFECTIVE TREES THAT
****  MUST BE CUT DOWN
 39   SAVEX        121    K0                  150
** BLOCK 39 (SAVEX 121) IDENTIFIES HARVESTABLE TREES IN PRINTOUT
 150  HOLD         23                         166        5
** BLOCK 150 SHEAR TERRAIN SET TIME
 151  ASSIGN       6      V3                  152
** BLOCK 151 DETERMINE DISTANCE BETWEEN TREE AND MACHINE REFERENCE POINT
 152  ASSIGN       5      FN13                153
** BLOCK 152 DETERMINES BACK-UP DISTANCE
 153  MATCH        97                         154
** BLOCK 153 HOLDS SHEAR UNTIL OPERATOR IS PREPARED TO BACK-UP
 154  HOLD         24                         155        1      FN14
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** BLOCK 154 BACK-UP TIME
 155  SAVEX         10-   P5                       156
** BLOCK 155 CORRECTS MACHINES LOCATION RELATIVE TO BACK-UP DISTANCE
 156  MATCH         98                             157
** BLOCK 156 HOLDS OPERATOR FOR THE MACHINE TO BACK-UP
 157  MATCH         100                            158
** BLOCK 157 HOLDS MACHINE FOR OPERATOR TO PREPARE FOR ADVANCE 1
 158  ASSIGN        4     V4                       159
** BLOCK 158 COMPUTES ADVANCE 1 DISTANCE
 159  HOLD          25                             160          1     FN15
** BLOCK 159 ADVANCE 1 TIME
 160  SAVEX         10+   P4                       161
** BLOCK 160 CORRECT MACHINE POSITION RELATIVE TO ADVANCE 1 DISTANCE
 161  MATCH         101                            162
** BLOCK 161 HOLDS OPERATOR FOR THE MACHINE TO COMPLETE ADVANCE 1
 162  MATCH         103                            163
** BLOCK 162 HOLDS MACHINE FOR OPERATOR TO PREPARE FOR SLUE TO TREE
 163  SAVEX         15    V5                       164
** BLOCK 163 HELPS BLOCK 164 COMPUTE THE SLUE TO TREE DISTANCE
 164  ASSIGN        7     FN57                     165
** BLOCK 164 COMPUTES THE SLUE TO TREE DISTANCE
 165  HOLD          26                             166          1     FN12
** BLOCK 165 SLUE TO TREE TIME
 166  ASSEMBLE      3                              198
** BLOCK 166 HOLDS SHEAR UNTIL  SHEAR IS OPENED,SHEAR TERRAIN SET IS
****  MADE IF TREE IS HARVESTABLE, AND SLUE TO THEE IS COMPLETE
 198  SAVEX         20    K10                      167
** BLOCK 198 SETS SAVEX 20 TO PERMIT GRAPPLE TO SLUE TO TREE AFTER
****  SHEAR HAS COMPLETED THE SLUE TO TREE
 167  MATCH         104                            168
** BLOCK 167 HOLDS OPERATOR UNTIL SHEAR HAS COMPLETED SLUE TO TREE
 168  MATCH         106                   FN    25
** BLOCK 168 HOLDS MACHINE FOR OPERATOR TO PREPARE FOR ADVANCE 2  AND
****  ROUTES TRANSACTION RELATIVE TO X LOCTION OF TREE (IF TREE BETWEEN
****  60 AND 110 X LOCATION IT COULD INTERFER WITH GRAPPLE DURING
****  ADVANCE 2, IN THIS CASE THE TRANSACTION IS ROUTED TO BLOCK 196 TO
****  CREATE A HOLD ON ADVANCE 2 UNTIL THE GRAPPLE IS CLEAR, FOR TREE X
****  LOCATION NOT BETWEEN 60 AND 110 THE TRANSACTION IS ROUTED TO
****  BLOCK 169)
 196  SAVEX         113   C1                       40
** BLOCK 196 (SAVEX 113) RECORDS TIME WHEN TREE IS AT BLOCK 196
 40   COMPARE       X30   G     K6                 41
** BLOCK 40 HOLDS SHEAR ADVANCE 2 FOR TREES WITH X LOCATION BETWEEN
****  60 AND 110 UNTIL  GRAPPLE IS CLEAR WITH LAST TREE
 41   SAVEX         114   C1                       169
** BLOCK 41 (SAVEX 114) RECORDS TIME WHEN TREE IS AT BLOCK 41
 169  ASSIGN        4     K40                      170
** BLOCK 169 ASSIGNS THE STANDARD ADVANCE 2 DISTANCE TO PARAMETER 4
 170  HOLD          27                             171          1     FN15
** BLOCK 170 ADVANCE 2 TIME
 171  SAVEX         10+   P4                       172
** BLOCK 171 CORRECTS MACHINE POSITION RELATIVE TO ADVANCE 2
 172  MATCH         107                            173
** BLOCK 172 HOLD OPERATOR FOR MACHINE TO COMPLETE ADVANCE 2
 173  HOLD          28                    FN    22          10
** BLOCK 173 TIME REQUIRED TO LOWER SHEAR TO GROUND FOR FELLING, ALSO
****  ROUTES TRANSACTION RELATIVE TO GRADE OF TREE (IF DEFECTIVE (P6=5),
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****  TRANSACTION IS ROUTED TO BLOCK 174 TO SIMULATE SHEAR FELLING A
****  DEFECTIVE TREE. IF HARVESTABLE (P6=10),TRANSACTION IS ROUTED TO
****  BLOCK 200 TO SIMULATE THE SHEARING OF A HARVESTABLE TREE IN
****  COORDINATION WITH THE GRAPPLE)
 174  HOLD          29                          175           1      FN17
** BLOCK 174 SIMULATES TIME TO SHEAR A DEFECTIVE TREE
 175  HOLD          30                          176          20
** BLOCK 175 TIME FOR TREE TO FALL
 176  SAVEX         11      X5                  546
** BLOCK 176 RECORDS THE X POSITION OF THE SHEAR FOR REFERENCE IN
****  COMPUTING INITIAL SLUE DISTANCES WITH NEXT TREE
 546  SAVEX         116     C1                  547
** BLOCK 546 (SAVEX 116) RECORDS TIME WHEN TREE IS AT BLOCK 546
 547  SAVEX         117     C1                  548
** BLOCK 547 (SAVEX 117) RECORDS TIME WHEN TREE IS AT BLOCK 547
 548  SAVEX         120     C1                  549
** BLOCK 548 (SAVEX 120) RECORDS TIME WHEN TREE IS AT BLOCK 548
 549  SAVEX         122     C1                  46
** BLOCK 549 (SAVEX 122) RECORDS TIME WHEN TREE IS AT BLOCK 549
 200  HOLD          35                          42            1      FN23
** BLOCK 200 SIMULATES TIME FOR PHASE 1 SHEARING OF A HARVESTABLE TREE
 42   SAVEX         116     C1                  201
** BLOCK 42 (SAVEX 116) RECORDS TIME WHEN TREE IS AT BLOCK 42
 201  MATCH         246                         43
** BLOCK 201 HOLDS SHEAR FOR GRAPPLE TO BE READY TO GRASP THE TREE
****  BEFORE SHEAR STARTS PHASE 2 CUT TO SEVER THE TREE
 43   SAVEX         117     C1                  199
** BLOCK 43 (SAVEX 117) RECORDS TIME WHEN TREE IS AT BLOCK 43
 199  SAVEX         20      K5                  202
** BLOCK 199 SETS SAVEX 20 TO HOLD THE GRAPPLE ON THE NEXT TREE UNTIL
****  THE SHEAR HAS COMPLETED THE SLUE TO TREE
 202  HOLD          36                          203           1      FN24
** BLOCK 202 SIMULATES TIME FOR PHASE 2 SHEARING OF A HARVESTABLE TREE
 203  MATCH         248                         44
** BLOCK 203 HOLDS GRAPPLE TO COMPLETE THE PHASE 2 SHEARING THUS
****  SEVERING THE STEM
 44   SAVEX         120     C1                  204
** BLOCK 44 (SAVEX 120) RECORDS TIME WHEN TREE IS AT BLOCK 44
 204  MATCH         255                         45
** BLOCK 204 HOLDS THE RAISING OF THE SHEAR FOR THE GRAPPLE TO LIFT THE
****  TREE THUS PROVIDING CLEARANCE FOR RAISING OF THE SHEAR
 45   SAVEX         122     C1                  205
** BLOCK 45 (SAVEX 122) RECORDS TIME WHEN TREE IS AT BLOCK 45
 205  HOLD          37                          206          10
** BLOCK 205 SIMULATES THE TIME TO RAISE THE SHEAR TO THE TRAVEL AND
****  SLUE POSITION
 206  SAVEX         11      X5                  46
** BLOCK 206 RECORDS THE X POSITION OF THE SHEAR FOR REFERENCE IN
****  COMPUTING INITIAL SLUE DISTANCES WITH THE NEXT TREE
 46   SAVEX         123     C1                  47
** BLOCK 46 (SAVEX 123) RECORDS TIME WHEN TREE IS AT BLOCK 46
 47   SAVEX         115     V12                 48
** BLOCK 47 (SAVEX 115) RECORDS ACTUAL OPERATING TIME OF SHEAR
 48   SAVEX         118     V13                 49
** BLOCK 48 (SAVEX 118) RECORDS TIME SHEAR WAITS ON OPERATOR AND
****  GRAPPLE AVAILABILITY
 49   SAVEX         119     V16                 110
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** BLOCK 49 (SAVEX 119) RECORDS TIME TREE IS IN CONTROL OF SHEAR
 110  PRINT          110   124                 207
** BLOCK 110 PRINTS PROCESS TIMES OF THE SHEAR
 207  MATCH          209                       550
** BLOCK 207 HOLDS THE ORIGINAL TRANSACTION THAT SEIZED FACILITY
****  20 WHILE A DUPLICATE TRANSACTION SIMULATES A TREE BEING PROCESSED
****  THROUGH THE SHEAR(THIS PROCEDURE IS A PROGRAMMING REQUIREMENT TO
****  INSURE THAT THE TRANSACTION THAT SEIZED FACILITY 20 ALSO RELEASES
****  IT)
 550  SAVEX          121   K0                  208
** BLOCK 550 ASSIGNS SAVEX 121 A VALUE OF 0 TO IDENTIFY HARVESTABLE
****  TREES IN THE PRINTOUT
 208  TERMINATE
** BLOCK 208 TERMINATES THE DUPLICATE TREE TRANSACTION AFTER IT HAS
****  SIMULATED A TREE BEING PROCESSED THROUGH THE SHEAR
 209  MATCH          207                       210
** BLOCK 209 HOLDS THE ORIGINAL TRANSACTION THAT SEIZED FACILITY
****  20 WHILE A DUPLICATE TRANSACTION SIMULATES A TREE BEING PROCESSED
****  THROUGH THE SHEAR
 210  RELEASE        20                        211
** BLOCK 210 RELEASES FACILITY 20 (SHEAR) AFTER A TREE TRANSACTION HAS
****  BEEN PROCESSED THROUGH THE SHEAR
 211  TERMINATE
** BLOCK 211 TERMINATES THE ORIGINAL TRANSACTION AFTER SHEAR SIMULATION
****  IS COMPLETE
 111  SAVEX          111   C1                  112
** BLOCK 111 (SAVEX 111) RECORDS TIME WHEN TREE IS AT BLOCK 111
 112  SAVEX          112   C1                  113
** BLOCK 112 (SAVEX 112) RECORDS TIME WHEN TREE IS AT BLOCK 112
 113  SAVEX          113   C1                  114
** BLOCK 113 (SAVEX 113) RECORDS TIME WHEN TREE IS AT BLOCK 113
 114  SAVEX          114   C1                  115
** BLOCK 114 (SAVEX 114) RECORDS TIME WHEN TREE IS AT BLOCK 114
 115  SAVEX          116   C1                  116
** BLOCK 115 (SAVEX 116) RECORDS TIME WHEN TREE IS AT BLOCK 115
 116  SAVEX          117   C1                  117
** BLOCK 116 (SAVEX 117) RECORDS TIME WHEN TREE IS AT BLOCK 116
 117  SAVEX          118   C1                  118
** BLOCK 117 (SAVEX 118) RECORDS TIME WHEN TREE IS AT BLOCK 117
 118  SAVEX          120   C1                  119
** BLOCK 118 (SAVEX 120) RECORDS TIME WHEN TREE IS AT BLOCK 118
 119  SAVEX          122   C1                  46
** BLOCK 119 (SAVEX 122) RECORDS TIME WHEN TREE IS AT BLOCK 119
 225  QUEUE          3     K1                  226
** BLOCK 255 QUEUE FOR TREE TRANSACTION AWAITING PROCESSING THROUGH
****  THE GRAPPLE
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*                    SUBPROGRAM FOR GRAPPLE SIMULATION
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 226  SEIZE          45                        224
** BLOCK 226 SEIZES FACILITY 45 WHICH IS THE GRAPPLE
 224  SPLIT                                    281   227
** BLOCK 224 FORMS A DUPLICATE TREE TRANSACTION TO PROCESS THROUGH THE
****  GRAPPLE WHILE HOLDING THE ORIGINAL TRANSATION TO RELEASE FACILITY
****  45 AS A REQUIREMENT OF PROGRAMMING PROCEDURE
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 227  SAVEX        21     P1                   228
** BLOCK 227 ASSIGNS SAVEX 21 THE DBH VALUE OF THE CURRENT TRANSACTION
****  IN THE GRAPPLE
 228  SAVEX        22     P2                   229
** BLOCK 228 ASSIGNS SAVEX 22 THE HEIGHT  VALUE OF THE CURRENT
****  TRANSACTION IN THE GRAPPLE
 229  SAVEX        23     P3                   230
** BLOCK 229 ASSIGNS SAVEX 23 THE DENSITY VALUE OF THE CURRENT
****  TRANSACTION IN THE GRAPPLE
 230  SAVEX        24     P4                   231
** BLOCK 230 ASSIGNS SAVEX 24 THE Y LOCATION OF THE CURRENT
****  TRANSACTION IN THE GRAPPLE
 231  SAVEX        25     P5                   232
** BLOCK 231 ASSIGNS SAVEX 25 THE X LOCATION OF THE CURRENT
****  TRANSACTION IN THE GRAPPLE
 232  SAVEX        26     P6                   233
** BLOCK 232 ASSIGNS SAVEX 26 THE TREE GRADE (DEFECTIVE OR HARVESTABLE)
****  OF THE CURRENT TRANSACTION IN THE GRAPPLE
 233  SAVEX        27     P7                   234
** BLOCK 233 ASSIGNS SAVEX 27 THE TERRAIN CLASSIFICATION FOR THE
****  CURRENT TRANSACTION IN THE GRAPPLE
 234  SAVEX        28     P8                   460
** BLOCK 234  ASSIGNS SAVEX 28 THE TYPE CUT (CLEAR OR THIN) FOR THE
****  CURRENT TRANSACTION IN THE GRAPPLE
 460  SAVEX        130    P3                   461
** BLOCK 460 (SAVEX 130) RECORDS THE NUMBER OF THE TREE AT THE GRAPPLE
 461  SAVEX        131    C1                   235
** BLOCK 461 (SAVEX 131) RECORDS TIME WHEN TREE IS AT BLOCK 461
 235  COMPARE       X20   G     KR             462
** BLOCK 235  HOLDS THE GRAPPLE UNTIL THE SHEAR HAS COMPLETED THE SLUE
****  TO TREE
 462  SAVEX        132    C1                   238
** BLOCK 462 (SAVEX 132) RECORDS TIME WHEN TREE IS AT BLOCK 462
 238  SAVEX        16     V6                   239
** BLOCK 238 HELPS BLOCK 239 COMPUTE GRAPPLE SLUE DISTANCE TO TREE
 239  ASSIGN       5      FN40                 240
** BLOCK 239 COMPUTES GRAPPLE SLUE DISTANCE TO TREE
 240  HOLD         47                          241       1      FN27
** BLOCK 240 SIMULATES SLUE TIME FOR EMPTY GRAPPLE TO TREE
 241  HOLD         48                          242       10
** BLOCK 241 SIMULATES TIME TO UNFOLD GRAPPLE 60 DEGREES
 242  SPLIT                                    244    243
** BLOCK 242 FORMS 2 DUPLICATE TRANSATION TO SIMULTANEOUSLY SIMULATE
****  COMPLETING GRAPPLE ROTATION AND GRAPPLE LOWERING
 243  HOLD         49                          245       1      FN29
** BLOCK 243 SIMULATES THE TIME FOR ROTATION OF GRAPPLE THE REMAINING
****  30 DEGREES
 244  HOLD         50                          245       5
** BLOCK 244 SIMULATES THE TIME FOR LOWERING OF THE GRAPPLE FROM THE
****  SLUE POSITION TO TREE GRASPING POSITION
 245  ASSEMBLE     2                           463
** BLOCK 245 HOLDS GRAPPLE UNTIL GRAPPLE ROTATION IS COMPLETED AND
****  GRAPPLE LOWERING IS COMPLETED
 463  SAVEX        133    C1                   246
** BLOCK 463 (SAVEX 133) RECORDS TIME WHEN TREE IS AT BLOCK 463
 246  MATCH        201                         464
** BLOCK 246 HOLDS SHEAR FOR GRAPPLE TO BE READY TO GRASP THE TREE
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****  BEFORE SHEAR STARTS PHASE 2 CUT TO SEVER THE TREE
 464  SAVEX        134    C1                  247
** BLOCK 464 (SAVEX 134) RECORDS TIME WHEN TREE IS AT BLOCK 464
 247  HOLD         51                         248        1       FN28
** BLOCK 247 SIMULATES GRAPPLE CLOSING TIME ON THE TREE
 248  MATCH        203                        249
** BLOCK 248 HOLDS THE GRAPPLE UNTIL THE SHEAR SEVERS THE TREE
 249  HOLD         52                         250        2
** BLOCK 249 SIMULATES TIME TO LIFT THE TREE THROUGH 10 DEGREES
****  OF GRAPPLE ARM
 250  SPLIT                                   251   252
** BLOCK 250 HELPS BLOCK 251 FORM 3 DUPLICATE TRANSACTIONS TO
****  SIMULTANEOUSLY SIMULATE THE ROTATION OF GRAPPLE TO SLUE POSITION
****  NO. 5, SETTING OF THE TREE SUPPORT, AND THE LIFTING OF THE TREE
****  TO SLUE POSITION
 251  SPLIT                                   254   253
** BLOCK 251 HELPS BLOCK 250 FORM 3 DUPLICATE TRANSACTIONS TO
****  SIMULTANEOUSLY SIMULATE THE ROTATION OF GRAPPLE TO SLUE POSITION
****  NO. 5, SETTING OF THE TREE SUPPORT, AND THE LIFTING OF THE TREE
****  TO SLUE POSITION
 252  HOLD         53                         256        1       FN30
** BLOCK 252 SIMULATES THE TIME FOR THE GRAPPLE TO ROTATE TO SLUE
****  POSITION (TERRAIN SETTING NO. 5)
 253  HOLD         54                         256        3
** BLOCK 253 SIMULATES THE TIME TO SET THE TREE SUPPORT
 254  HOLD         55                         255        2
** BLOCK 254 SIMULATES THE TIME TO RAISE THE TREE TO SLUE POSITION
 255  MATCH        204                        256
** BLOCK 255 HOLDS THE RAISING OF THE SHEAR FOR THE GRAPPLE TO LIFT THE
****  TREE THUS PROVIDING CLEARANCE FOR RAISING OF THE SHEAR
 256  ASSEMBLE     3                          257
** BLOCK 256 HOLDS GRAPPLE UNTIL ROTATION OF GRAPPLE TO SLUE POSITION
****  NO. 5, SETTING OF THE TREE SUPPORT, AND THE LIFTING OF THE TREE
****  TO SLUE POSITION HAS BEEN COMPLETED
 257  SAVEX        30     K5                  258
** BLOCK 257 SETS SAVEX 30 TO HOLD SHEAR ADVANCE 2 FOR NEXT TREE WITH X
****  LOCATION BETWEEN 60 AND 110 UNTIL GRAPPLE AND TREE ARE CLEAR FOR
****  THE SHEAR ADVANCE 2
 258  HOLD         56                         465        1       FN31
** BLOCK 258 SIMULATES SLUE TIME OF GRAPPLE WITH TREE
 465  SAVEX        136    C1                  260
** BLOCK 465 (SAVEX 136) RECORDS TIME WHEN TREE IS AT BLOCK 465
 260  COMPARE      X35    G      K8           466
** BLOCK 260 HOLDS GRAPPLE RAISING TO DELIMBER HOLD POSITION FOR
****  CLEARANCE OF DELIMBER WITH LAST TREE
 466  SAVEX        137    C1                  261
** BLOCK 466 (SAVEX 137) RECORDS TIME WHEN TREE IS AT BLOCK 466
 261  SPLIT                                   263   262
** BLOCK 261 FORMS 2 DUPLICATE TRANSACTIONS TO SIMULTANEOUSLY SIMULATE
****  ROTATING GRAPPLE TO TERRAIN SET POSITION NO. 3, AND RAISING OF
****  TREE TO DELIMBER HOLD POSITION
 262  HOLD         57                         264        3
** BLOCK 262 SIMULATES TIME TO ROTATE GRAPPLE AND TREE TO TERRAIN SET
****  POSITION NO. 3
 263  HOLD         58                         264        15
** BLOCK 263 SIMULATES TIME TO RAISE TREE AND GRAPPLE TO DELIMBER HOLD
****  POSITION
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 264  ASSEMBLE     2                          265
** BLOCK 264 HOLDS GRAPPLE UNTIL COMPLETION OF  ROTATION OF GRAPPLE
****  AND TREE TO POSITION NO. 3 AND RAISING OF TREE AND GRAPPLE TO
****  DELIMBER HOLD POSITION
 265  SAVEX        30    K10                  467
** BLOCK 265 SETS SAVEX 30 TO RELEASE SHEAR ADVANCE 2 FOR NEXT TREE WITH
****  X LOCATION BETWEEN 60 AND 110 SINCE GRAPPLE AND TREE ARE CLEAR FOR
****  SHEAR ADVANCE 2
 467  SAVEX        140   C1                   266
** BLOCK 467 (SAVEX 140) RECORDS TIME WHEN TREE IS AT BLOCK 467
 266  MATCH        302                        468
** BLOCK 266 HOLDS GRAPPLE FOR   DELIMBER CLEARANCE TO RECEIVE ANOTHER
****  TREE
 468  SAVEX        142   C1                   267
** BLOCK 468 (SAVEX 142) RECORDS TIME WHEN TREE IS AT BLOCK 468
 267  HOLD         59                         268         5
** BLOCK 267 SIMULATES TIME FOR RAISING AND POSITIONING TREE IN DELIMBER
 268  HOLD         60                         269         1     FN26
** BLOCK 268 SIMULATES TIME TO OPEN GRAPPLE TO RELEASE TREE IN DELIMBER
 269  MATCH        303                        270
** BLOCK 269 HOLDS DELIMBER RECEIVER FOR GRAPPLE TO OPEN AND RELEASE
****  THE TREE
 270  MATCH        306                        271
** BLOCK 270 HOLDS GRAPPLE FOR DELIMBER RECEIVER TO LIFT TREE OUT OF
****  GRAPPLE TO PROVIDE CLEARANCE FOR LOWERING GRAPPLE
 271  SPLIT                                   272   275
** BLOCK 271 FORMS 2 DUPLICATE TRANSACTIONS TO SIMULTANEOUSLY SIMULATE
**** LOWERING OF GRAPPLE TO DELIMBER WAIT POSITION AND FOLDING UNDER
****  OF THE GRAPPLE
 272  HOLD         61                         273         5
** BLOCK 272 SIMULATES THE TIME TO LOWER THE GRAPPLE TO DELIMBER WAIT
****  POSITION
 273  SPLIT                                   276   274
** BLOCK 273 FORMS 2 DUPLICATE TRANSACTIONS TO SIMUTANEOUSLY SIMULATE
****  FOLDING TREE SUPPORT AND LOWERING OF GRAPPLE TO SLUE POSITION
 274  HOLD         62                         277         3
** BLOCK 274 SIMULATES TIME FOR FOLDING TREE SUPPORT
 275  HOLD         63                         277         10
** BLOCK 275 SIMULATES TIME TO FOLD THE GRAPPLE UNDER
 276  HOLD         64                         277         10
** BLOCK 276 SIMULATES TIME TO LOWER GRAPPLE FROM DELIMBER WAIT
****  POSITION TO SLUE POSITION
 277  ASSEMBLE     3                          278
** BLOCK 277 HOLDS GRAPPLE UNTIL COMPLETION OF LOWERING OF GRAPPLE TO
****  SLUE POSITION, FOLDING OF TREE SUPPORT, AND FOLDING UNDER OF
****  GRAPPLE
 278  MATCH        307                        279
** BLOCK 278 HOLDS THE LOWERING OF THE DELIMBER RECEIVER UNTIL THE GRAPPLE
****  HAS BEEN LOWERED TO THE SLUE POSITION TO AVOID INTERFERENCE OF
****  GRAPPLE AND TREE
 279  MATCH        281                        469
** BLOCK 279 HOLDS THE ORIGINAL TRANSACTION THAT SEIZED FACILITY
****  45 WHILE A DUPLICATE TRANSACTION SIMULATES A TREE BEING PROCESSED
****  THROUGH THE GRAPPLE(THIS PROCEDURE IS A PROGRAMMING REQUIREMENT TO
****  INSURE THAT THE TRANSACTION THAT SEIZED FACILITY 45 ALSO RELEASES
****  IT)
 469  SAVEX        143   C1                   470
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** BLOCK 469 (SAVEX 143) RECORDS TIME WHEN TREE IS AT BLOCK 469
 470  SAVEX       135   V17            471
** BLOCK 470 (SAVEX 135) RECORDS ACTUAL OPERATING TIME OF GRAPPLE
 471  SAVEX       138   V18            472
** BLOCK 471 (SAVEX 138) RECORDS TIME GRAPPLE WAITS ON SHEAR AND
****  DELIMBER AVAILABILITY
 472  SAVEX       139   V19            473
** BLOCK 472 (SAVEX 139) RECORDS TIME TREE IS IN CONTROL OF GRAPPLE
 473  PRINT       130   144            280
** BLOCK 473 PRINTS PROCESS TIMES OF THE GRAPPLE
 280  TERMINATE
** BLOCK 280 TERMINATES THE DUPLICATE TREE TRANSACTION AFTER IT HAS
****  SIMULATED A TREE BEING PROCESSED THROUGH THE GRAPPLE
 281  MATCH       279                  282
** BLOCK 281 HOLDS THE ORIGINAL TRANSACTION THAT SEIZED FACILITY 45
****  WHILE A DUPLICATE TRANSACTION SIMULATES A TREE BEING PROCESSED
****  THROUGH THE GRAPPLE
 282  RELEASE     45                   283
** BLOCK 282 RELEASES FACILITY 45 (GRAPPLE) AFTER A TREE TRANSACTION
****  HAS BEEN PROCESSED THROUGH THE GRAPPLE
 283  TERMINATE
** BLOCK 283 TERMINATES THE ORIGINAL TRANSACTION AFTER GRAPPLE
****  SIMULATION IS COMPLETE FOR THE TRANSACTION
 300  QUEUE       4     K1             301
** BLOCK 300 QUEUE FOR TREE TRANSACTIONS AWAITING PROCESSING THROUGH
****  THE DELIMBER
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*                     SUBPROGRAM FOR DELIMBER SIMULATION
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 301  SEIZE       75                   480
** BLOCK 301 SEIZES FACILITY 75 WHICH IS THE DELIMBER
 480  SAVEX       150   P3             481
** BLOCK 480 (SAVEX 150) RECORDS THE NUMBER OF THE TREE AT THE DELIMBER
 481  SAVEX       151   C1             302
** BLOCK 481 (SAVEX 151) RECORDS TIME WHEN TREE IS AT BLOCK 481
 302  MATCH       266                  482
** BLOCK 302 HOLDS GRAPPLE FOR DELIMBER CLEARANCE TO
****  RECEIVE ANOTHER TREE
 482  SAVEX       152   C1             303
** BLOCK 482 (SAVEX 152) RECORDS TIME WHEN TREE IS AT BLOCK 482
 303  MATCH       269                  304
** BLOCK 303 HOLDS DELIMBER RECEIVER FOR GRAPPLE TO OPEN AND RELEASE
****  THE TREE
 304  SAVEX       35    K5             305
** BLOCK 304 SETS SAVEX 35 TO KEEP GRAPPLE FROM RAISING ABOVE SLUE
****  LEVEL WITH A NEW TREE WHILE ONE IS IN THE DELIMBER IN A POSITION
****  THAT WILL INTERFER  WITH THE GRAPPLE RAISING THE TREE  PAST THE
****  SLUE POSITION
 305  HOLD        76                   306          5
** BLOCK 305 SIMULATES TIME FOR RAISING THE DELIMBER RECEIVER TO LIFT
****  THE TREE OUT OF THE GRAPPLE
 306  MATCH       270                  307
** BLOCK 306 HOLDS GRAPPLE UNTIL DELIMBER RECEIVER LIFTS THE TREE CLEAR
****  OF THE GRAPPLE
 307  MATCH       278                  308
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** BLOCK 307 HOLDS LOWERING OF DELIMBER RECEIVER UNTIL GRAPPLE HAS BEEN
****  LOWERED TO GIVE CLEARANCE TO LOWER THE TREE
 308  HOLD         77                     309        5
** BLOCK 308 SIMULATES TIME FOR DELIMBER RECEIVER TO LOWER THE TREE INTO
****  THE DELIMBER
 309  HOLD         78                     310        5
** BLOCK 309 SIMULATES TIME FOR DELIMBER TO CLOSE TREE RETAINING ARMS
 310  HOLD         79                     311        40
** BLOCK 310 SIMULATES TIME FOR DELIMBER TO DELIMB THE TREE
 311  HOLD         80                     483        5
** BLOCK 311 SIMULATES TIME FOR DELIMBER TO OPEN TREE RETAINING ARMS
 483  SAVEX        153   C1               312
** BLOCK 483 (SAVEX 153) RECORDS TIME WHEN TREE IS AT BLOCK 483
 312  MATCH        367                    484
** BLOCK 312 HOLDS DELIMBER TREE DISCHARGE FOR BUCKER CLEARANCE TO
****  RECEIVE A NEW TREE
 484  SAVEX        154   C1               314
** BLOCK 484 (SAVEX 154) RECORDS TIME WHEN TREE IS AT BLOCK 484
 314  HOLD         81                     315        10
** BLOCK 314 SIMULATES TIME FOR DELIMBER TO DISCHARGE TREE WITH DELIMBER
****  DISCHARGING FLIPS
 315  SAVEX        35    K10              316
** BLOCK 315 SETS SAVEX 35 TO ALLOW THE GRAPPLE TO RAISE A TREE PAST
****  SLUE LEVEL SINCE THE CURRENT TREE BEING PROCESSED THROUGH THE
****  DELIMBER HAS BEEN FLIPPED OVER TO THE BUCKER AND THEREFORE CAN NOT
***** INTERFER  WITH THE GRAPPLE RAISING A TREE ABOVE THE SLUE LEVEL
 316  MATCH        368                    317
** BLOCK 316 HOLDS BUCKER RECEIVING FLIP FOR DELIMBER DISCHARGING FLIP
****  TO DISCHARGE THE TREE
 317  MATCH        371                    318
** BLOCK 317 HOLDS RETURN OF DELIMBER DISCHARGE FLIP FOR BUCKER
****  RECEIVING FLIPS TO RECEIVE TREE
 318  HOLD         82                     485        5
** BLOCK 318 SIMULATES TIME FOR DELIMBER DISCHARGE FLIP TO RETURN
 485  SAVEX        156   C1               486
** BLOCK 485 (SAVEX 156) RECORDS TIME WHEN TREE IS AT BLOCK 485
 486  SAVEX        155   V20              487
** BLOCK 486 (SAVEX 155) RECORDS ACTUAL OPERATING TIME OF DELIMBER
 487  SAVEX        158   V21              488
** BLOCK 487 (SAVEX 158) RECORDS TIME DELIMBER WAITS ON GRAPPLE AND
****  BUCKER AVAILABILITY
 488  SAVEX        159   V22              489
** BLOCK 488 (SAVEX 159) RECORDS TIME TREE IS IN CONTROL OF DELIMBER
 489  PRINT        150   159              319
** BLOCK 489 PRINTS PROCESS TIMES OF THE DELIMBER
 319  RELEASE      75                     320
** BLOCK 319 RELEASES FACILITY 75 (DELIMBER) AFTER A TREE TRANSACTION
****  HAS BEEN PROCESSED THROUGH THE DELIMBER
 320  TERMINATE
** BLOCK 320 TERMINATES THE TRANSACTION AFTER DELIMBER SIMULATION IS
****  COMPLETE FOR THE TRANSACTION
 340  QUEUE        5     K1               341
** BLOCK 340 QUEUE FOR TREE TRANSACTIONS AWAITING PROCESSING THROUGH THE
****  BUCKER
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*                  SUBPROGRAM FOR BUCKER SIMULATION
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 341  SEIZE        95                      339
** BLOCK 341 SEIZES FACILITY 95 WHICH IS THE BUCKER
 339  SPLIT                                413   342
** BLOCK 339 FORMS A DUPLICATE TREE TRANSACTION TO PROCESS THROUGH THE
****  BUCKER WHILE HOLDING THE ORIGINAL TRANSACTION TO RELEASE FACILITY
****  95 AS A REQUIREMENT OF PROGRAMMING PROCEDURE
 342  SAVEX        41    F1                343
** BLOCK 342 ASSIGNS SAVEX 41 THE DBH VALUE OF THE CURRENT TRANSACTION
****  IN THE BUCKER
 343  SAVEX        42    F2                344
** BLOCK 343 ASSIGNS SAVEX 42 THE HEIGHT VALUE OF THE CURRENT
****  TRANSACTION IN THE BUCKER
 344  SAVEX        43    F3                345
** BLOCK 344 ASSIGNS SAVEX 43 THE TREE NUMBER OF THE CURRENT
****  TRANSACTION IN THE BUCKER
 345  SAVEX        44    F4                346
** BLOCK 345 ASSIGNS SAVEX 44 THE Y LOCATION OF THE CURRENT TRANSACTION
****  IN THE BUCKER
 346  SAVEX        45    F5                347
** BLOCK 346 ASSIGNS SAVEX 45 THE X LOCATION OF THE CURRENT TRANSACTION
****  IN THE BUCKER
 347  SAVEX        46    F6                348
** BLOCK 347 ASSIGNS SAVEX 46 THE TREE GRADE (DEFECTIVE OR HARVESTABLE)
****  OF THE CURRENT TREE TRANSACTION IN THE BUCKER
 348  SAVEX        47    F7                349
** BLOCK 348 ASSIGNS SAVEX 47 THE TERRAIN CLASSIFICATION  OF THE
****  CURRENT TRANSACTION IN THE BUCKER
 349  SAVEX        48    F8                350
** BLOCK 349 ASSIGNS SAVEX 48 THE TYPE CUT (CLEAR OR THIN) FOR THE
****  CURRENT TRANSACTION IN THE BUCKER
 350  ASSIGN       2     FN32              351
** BLOCK 350 SETS UP CONTROL FOR 65-80 FT. TREES (ASSIGNS P2 THE VALUE
****  OF 10 IF TREE IS 65 TO 80 FT. AND 0 OTHERWISE)
 351  SAVEX        51    V7                500
** BLOCK 351 RECORDS A COMPARISON BETWEEN THE CURRENT BUCKER SHEAR
****  SETTING AND THE SETTING NEEDED TO PROCESS THE CURRENT TREE IN
****  THE BUCKER
 500  SAVEX        160   F3                352
** BLOCK 500 (SAVEX 160) RECORDS THE NUMBER OF THE TREE IN THE BUCKER
 352  ASSIGN       3     FN33              501
** BLOCK 352 ASSIGNS P3 THE VALUE OF 10 IF A CHANGE IN BUCKER SHEAR
****  POSITION IS NEEDED FOR THIS TREE, AND THE VALUE OF 0 IF NO
****  CHANGE IS NEEDED
 501  SAVEX        161   C1                353
** BLOCK 501 (SAVEX 161) RECORDS TIME WHEN TREE IS AT BLOCK 501
 353  SPLIT                                354   409
** BLOCK 353 HELPS BLOCK  354 FORM DUPLICATE TRANSACTIONS
****  TO SIMULTANEOUSLY SIMULATE SHEAR POSITIONING AND FLIP RETURN
****  ON FORWARD AND REAR FLIPS
 354  SPLIT                                355   410
** BLOCK 354 HELPS BLOCK 353 FORM DUPLICATE TRANSACTIONS
****  TO SIMULTANEOUSLY SIMULATE SHEAR POSITIONING AND FLIP RETURN ON
****  FORWARD AND REAR FLIPS
 355  SPLIT                                364   366
** BLOCK 355 FORMS A DUPLICATE TRANSACTION TO SIMULATE SETTING SHEARS
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**** FOR EXPANSION SIMULTANEOUSLY WITH POSITIONING REAR SHEAR AND
**** RETURNING FORWARD AND REAR FLIPS
 356  HOLD          96                    FN     35
** BLOCK 356 ROUTE TRANSACTION TO BLOCK 357 TO RETURN BUCKER RECEIVING
**** FLIP IF THE TREES CURRENTLY BEING PROCESSED ARE 65  TO  80 FT
**** LONG, TO BLOCK 358 TO RETURN BUCKER DISCHARGING FLIP IF TREES THAT
**** ARE BEING PROCESSED ARE NOT 65 TO 80 FT LONG
 357  HOLD          97                          365           10
** BLOCK 357 SIMULATES TIME FOR RETURN OF BUCKER RECEIVING FLIP
 358  HOLD          98                          365           10
** BLOCK 358 SIMULATES TIME FOR RETURN OF BUCKER DISCHARGING FLIP,
**** EXCLUDES REAR ASSEMBLY IF LAST TREE WAS 65 TO 80 FT LONG
 359  HOLD          99                    FN     36
** BLOCK 359 ROUTE TRANSACTION TO BLOCK 360 TO RETURN BUCKER DISCHARGING
**** FLIP AND ROTATE DISCHARGE FLIP ASSEMBLY DOWN IF TREE IS 65 TO 80
**** FT. OR  TO BLOCK 362 TO ROTATE DISCHARGE FLIP ASSEMBLY UP IF THIS
**** TREE IS NOT 65 TO 80 FT. LONG
 360  HOLD          100                         361           10
** BLOCK 360 SIMULATES TIME FOR RETURN OF BUCKER DISCHARGING FLIP
 361  HOLD          101                         365           20
** BLOCK 361 SIMULATES TIME FOR ROTATING BUCKER DISCHARGING FLIP
**** ASSEMBLY DOWN
 362  HOLD          102                         365           20
** BLOCK 362 SIMULATES TIME FOR ROTATING BUCKER DISCHARGING FLIP
**** ASSEMBLY  UP
 363  HOLD          103                         365           30
** BLOCK 363 SIMULATES TIME TO ROTATE REAR SHEAR UP OR DOWN
 364  HOLD          104                         365           10
** BLOCK 364 SIMULATES TIME TO RETURN BUCKER FORWARD DISCHARGING FLIPS
 365  ASSEMBLE      3                           502
** BLOCK 365 HOLDS TRANSACTIONS FOR COMPLETION OF REAR SHEAR POSITIONING
**** AND FLIP RETURN OF FORWARD AND REAR FLIPS
 502  SAVEX         162    C1                    367
** BLOCK 502 (SAVEX 162) RECORDS TIME WHEN TREE IS AT BLOCK 502
 366  HOLD          105                         370            5
** BLOCK 366 SIMULATES TIME FOR POSITIONING BUCKER SHEARS TO ALLOW
**** FOR EXPANSION DURING SHEARING ACTION
 367  MATCH         312                         503
** BLOCK 367 HOLDS DELIMBER TREE DISCHARGE FOR BUCKER CLEARANCE TO
**** RECEIVE A NEW TREE
 503  SAVEX         163    C1                    368
** BLOCK 503 (SAVEX 163) RECORDS TIME WHEN TREE IS AT BLOCK 503
 368  MATCH         316                         369
** BLOCK 368 HOLDS BUCKER RECEIVING FLIP FOR DELIMBER DISCHARGING FLIP
**** TO DISCHARGE THE TREE
 369  HOLD          112                         370           15
** BLOCK 369 SIMULATES TIME FOR BUCKER RECEIVING FLIP TO FLIP THE
**** TREE INTO THE BUCKER
 370  ASSEMBLE      2                           371
** BLOCK 370 IS AN ASSEMBLE BLOCK THAT REQUIRES COMPLETION OF REAR
**** SHEAR SET, RETURN AND POSITION OF FLIPS, BUCKER RECEIPT OF
**** TREE BEFORE CONTINUED  BUCKER ACTION IS ALLOW TO COMMENCE
 371  MATCH         317                         372
** BLOCK 371 HOLDS RETURN OF DELIMBER DISCHARGE FLIP FOR BUCKER RECEIVING
**** FLIPS TO RECEIVE TREE
 372  HOLD          106                         406            1     FN38
** BLOCK 372 SIMULATES TIME FOR BUCKER SHEARS TO CUT THE TREE INTO
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**** THE DESIRED LENGTHS
 373  SPLIT                                       374   375
** BLOCK 373 FORMS A DUPLICATE TRANSACTION TO SIMULTANEOUSLY SIMULATE
****  OPENING OF THE SHEAR AND RETURN OF THE BUCKER RECEIVING FLIP
 374  HOLD          107                         376          10
** BLOCK 374 SIMULATES TIME TO OPEN BUCKER SHEARS
 375  HOLD          108                         376          10
** BLOCK 375 SIMULATES TIME TO RETURN BUCKER RECEIVING FLIPS
 376  ASSEMBLE     2                            504
** BLOCK 376 HOLDS BUCKER PROCESSING SEQUENCE UNTIL SHEARS HAVE
****  OPENED AND RECEIVING FLIPS RETURNED
 504  SAVEX         164    C1                   377
** BLOCK 504 (SAVEX 164) RECORDS TIME WHEN TREE IS AT BLOCK 504
 377  COMPARE        X180  L      K5            505
** BLOCK 377 HOLDS BUCKER PROGRESS UNTIL CONVEYER IS READY TO RECEIVE
****  TREE
 505  SAVEX         166    C1                   378
** BLOCK 505 (SAVEX 166) RECORDS TIME WHEN TREE IS AT BLOCK 505
 378  SPLIT                                     380   411
** BLOCK 378 FORMS A DUPLICATE TRANSACTION TO SIMULTANEOUSLY SIMULATE
****  FORWARD AND REAR BOLTS OF TREE BEING FLIPPED OUT OF BUCKER
 379  HOLD          109                         382          10
** BLOCK 379 SIMULATES TIME FOR FLIPPING REAR TREE BOLT OUT OF BUCKER
****  INTO CONVEYER
 380  HOLD          110                         382          10
** BLOCK 380 SIMULATES TIME FOR FLIPPING FRONT TREE BOLTS OUT OF
****  BUCKER INTO CONVEYER
 381  HOLD          111                         384          10
** BLOCK 381 SIMULATES TIME FOR FLIPPING REAR TREE BOLT AND TOP OUT OF
****  BUCKER ONTO THE GROUND IF TREE IS 65 TO 80 FT. LONG
 382  ASSEMBLE     2                            383
** BLOCK 382 HOLDS BUCKER PROGRESS UNTIL FORWARD AND REAR TREE BOLTS
****  HAVE BEEN FLIPPED OUT OF BUCKER
 383  SAVEX         50     P2                   404
** BLOCK 383 RECORDS BUCKER REAR SHEAR POSITION FOR CURRENT TREE
****  IN ORDER TO DETERMINE IF A CHANGE IN REAR SHEAR POSITION IS
****  NECESSARY TO PREPARE BUCKER FOR NEXT TREE
 384  ADVANCE                              FN    45
** BLOCK 384 ROUTES TRANSACTION TO BLOCK 385 IF CURRENT BUCKER TREE
****  IS 65 TO 80 FT TO RECORD X AND Y POSITIONS OF TREE TOP WHEN IT
****  IS FLIPPED OUT OF BUCKER ONTO THE GROUND OR TO BLOCK 382 IF TREE
****  IS NOT 65 TO 80 FT TO RELEASE THE ASSEMBLE BLOCK
 385  SAVEX         84     V15                  386
** BLOCK 385 ASSIGNS SAVEX 84 THE Y LOCATION WHERE THE UPPER BOLT AND
****  TOP OF THE CURRENT TRANSACTION IN THE BUCKER WAS DROPPED TO THE
****  GROUND
 386  SAVEX         85     K65                  382
** BLOCK 386 ASSIGNS SAVEX 85 THE X LOCATION WHERE THE UPPER BOLT AND
****  TOP OF THE CURRENT TRANSACTION IN THE BUCKER WAS DROPPED TO THE
****  GROUND
 398  ASSIGN        1      X41                  399
** BLOCK 398 REASSIGNS DBH TO PARAMETER 1 FROM SAVEX 41 WHERE IT WAS
****  ORIGINALLY STORED WHILE THE CURRENT TRANSACTION WAS BEING
****  PROCESSED IN BUCKER
 399  ASSIGN        2      X42                  400
** BLOCK 399 REASSIGNS HEIGHT TO PARAMETER 2 FROM SAVEX 42 WHERE IT WAS
****  ORIGINALLY STORED WHILE THE CURRENT TRANSACTION WAS BEING
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****  PROCESSED IN BUCKER
 400  ASSIGN        3      X43                   401
** BLOCK 400 REASSIGNS TREE NUMBER TO PARAMETER 3 FROM SAVEX 43 WHERE IT
****  WAS ORIGINALLY STORED WHILE THE CURRENT TRANSACTION WAS BEING
****  PROCESSED IN BUCKER
 401  ASSIGN        6      X46                   402
** BLOCK 401 REASSIGNS GRADE TO PARAMETER 6 FROM SAVEX 46 WHERE IT WAS
****  ORIGINALLY STORED WHILE THE CURRENT TRANSACTION WAS BEING
****  PROCESSED IN BUCKER
 402  ASSIGN        7      X47                   403
** BLOCK 402 REASSIGNS TERRAIN CLASSIFICATION TO PARAMETER 7 FROM SAVEX
****  47 WHERE IT WAS ORIGINALLY STORED WHILE THE CURRENT TRANSACTION
****  WAS BEING PROCESSED IN BUCKER
 403  ASSIGN        8      X48                   414
** BLOCK 403 REASSIGNS TYPE CUT TO PARAMETER 8 FROM SAVEX 48 WHERE IT
****  WAS ORIGINALLY STORED WHILE THE CURRENT TRANSACTION WAS BEING
****  PROCESSED IN BUCKER
 404  MATCH         413                          412
** BLOCK 404 HOLDS THE ORIGINAL TRANSACTION THAT SEIZED FACILITY
****  95 WHILE A DUPLICATE TRANSACTION SIMULATES A TREE BEING PROCESSED
****  THROUGH THE BUCKER(THIS PROCEDURE IS A PROGRAMMING REQUIREMENT TO
****  INSURE THAT THE TRANSACTION THAT SEIZED FACILITY 95 ALSO RELEASES
****  IT)
 406  ADVANCE                           FN     44
** BLOCK 406 ROUTES TRANSACTION TO BLOCK 407 IF TREE IS LONGER THAN 80
****  FT. TO RECORD THE X AND Y POSITION OF THE TOPS AS THEY ARE
****  DROPPED TO THE GROUND FROM THE BUCKER OR TO BLOCK 373 IF TREE IS
****  LESS THAN 80 FT TO AVOID BLOCK 407
 407  SAVEX         84     V14                   408
** BLOCK 407 ASSIGNS SAVEX 84 THE Y LOCATION WHERE THE TOP PORTION OF
****  THE CURRENT TRANSACTION IN THE BUCKER WAS DROPPED TO THE GROUND
 408  SAVEX         85     K80                   373
** BLOCK 408 ASSIGNS SAVEX 85 THE X LOCATION WHERE THE TOP PORTION OF
****  THE CURRENT TRANSACTION IN THE BUCKER WAS DROPPED TO THE GROUND
 409  ADVANCE                           FN     34
** BLOCK 409 ROUTES TRANSACTION TO BLOCK 356 TO SIMULATE RETURN OF
****  BUCKER FLIP IF THERE IS NO CHANGE IN BUCKER OR TO BLOCK 359 TO
****  SIMULATE RETURN AND POSITION OF BUCKER FLIP IF THERE IS A CHANGE
****  REQUIRED IN BUCKER SETTING TO PROCESS THIS TREE
 410  ADVANCE                           FN     37
** BLOCK 410 ROUTES TRANSACTION TO BLOCK 365 TO WAIT AT  ASSEMBLE
****  BLOCK IF NO CHANGE IS NEEDED IN BUCKER REAR SHEAR OR TO BLOCK
****  363 IF THERE IS A CHANGE NEEDED IN REAR SHEAR POSITION FOR
****  THIS TREE
 411  ADVANCE                           FN     39
** BLOCK 411 ROUTES TRANSACTION TO BLOCK 379 IF CURRENT BUCKER TREE
****  IS NOT 65 TO 80 FT. LONG TO SIMULATE FLIPING REAR BOLTS OUT OF
****  BUCKER TO CONVEYER OR TO BLOCK 381 IF CURRENT BUCKER TREE IS 65 TO
****  80 FT. LONG TO SIMULATE UPPER BOLT AND TOP BEING FLIPPED OUT OF
****  BUCKER TO THE GROUND
 412  TERMINATE
** BLOCK 412 TERMINATES THE DUPLICATE TREE TRANSACTION AFTER IT HAS
****  SIMULATED A TREE BEING PROCESSED THROUGH THE BUCKER
 413  MATCH         404                          398
** BLOCK 413 HOLDS THE ORIGINAL TRANSACTION THAT SEIZED FACILITY
****  95 WHILE A DUPLICATE TRANSACTION SIMULATES A TREE BEING PROCESSED
****  THROUGH THE BUCKER
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 414  ASSIGN         4      X84                      415
** BLOCK 414 ASSIGNS PARAMETER 4 OF THE TRANSACTION CURRENTLY IN THE
****  BUCKER THE Y LOCATION WHERE THE TOP PORTION OF THE TREE WAS
****  DROPPED TO THE GROUND
 415  ASSIGN         5      X85                      506
** BLOCK 415 ASSIGNS PARAMETER 5 OF THE TRANSACTION CURRENTLY IN THE
****  BUCKER THE X LOCATION WHERE THE TOP PORTION OF THE TREE WAS
****  DROPPED TO THE GROUND
 506  SAVEX          167    C1                       507
** BLOCK 506 (SAVEX 167) RECORDS TIME WHEN TREE IS AT BLOCK 506
 507  SAVEX          165    V23                      509
** BLOCK 507 (SAVEX 165) RECORDS ACTUAL OPERATING TIME OF BUCKER
 509  SAVEX          168    V24                      510
** BLOCK 509 (SAVEX 168) RECORDS TIME BUCKER WAITS ON DELIMBER AND
****  CONVEYER
 510  SAVEX          169    V25                      511
** BLOCK 510 (SAVEX 169) RECORDS TIME TREE IS IN CONTROL OF BUCKER
 511  PRINT          160    169                      416
** BLOCK 511 PRINTS PROCESS TIMES OF THE BUCKER
 416  RELEASE        95                              425
** BLOCK 416 RELEASES FACILITY 95 (BUCKER) AFTER A TREE TRANACTION
****  HAS BEEN PROCESSED THROUGH THE BUCKER
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*                  SUBPROGRAM FOR CONVEYER SIMULATION
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 425  SEIZE          120                             424
** BLOCK 425 SEIZES FACILITY 120 WHICH IS THE CONVEYER
 424  SPLIT                                          449   532
** BLOCK 424 FORMS A DUPLICATE TREE TRANSACTION TO PROCESS THROUGH THE
****  CONVEYER WHILE HOLDING THE ORIGINAL TRANSACTION TO RELEASE
****  FACILITY 120 AS A REQUIREMENT OF PROGRAMMING PROCEDURE
 532  SAVEX          180    K10                      525
** BLOCK 532 SETS SAVEX 180 TO 10 TO INDICATE CONVEYER IS BEING USED
 525  SAVEX          170    P3                       526
** BLOCK 525 (SAVEX 170) RECORDS THE NUMBER OF THE TREE IN THE CONVEYER
 526  SAVEX          171    C1                       426
** BLOCK 526 (SAVEX 171) RECORDS TIME WHEN TREE IS AT BLOCK 526
 426  SPLIT                                          427   433
** BLOCK 426 FORMS A DUPLICATE TRANSACTION TO SIMULATE THE SECOND
****  BOLT OF THE TREE BEING PROCESSED THROUGH THE CONVEYER
 427  SPLIT                                          428   439
** BLOCK 427 FORMS A DUPLICATE TRANSACTION TO SIMULATE THE THIRD
****  BOLT OF THE TREE BEING PROCESSED THROUGH THE CONVEYER
 428  HOLD           121                             429         2
** BLOCK 428 SIMULATES TIME TO CONVEY   THE FIRST BOLT BACK TO THE
****  CONVEYER STOP
 429  HOLD           122                             430         5
** BLOCK 429 SIMULATES TIME TO STOP THE FIRST BOLT IN THE CONVEYER
 430  HOLD           123                             431         10
** BLOCK 430 SIMULATES TIME TO OPEN THE CONVEYER SIDE GATE FOR THE
****  FIRST BOLT
 431  HOLD           124                             432         5
** BLOCK 431 SIMULATES TIME FOR THE FIRST BOLT TO FALL OUT OF THE
****  CONVEYER
 432  HOLD           125                             445         10
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** BLOCK 432 SIMULATES TIME TO CLOSE THE CONVEYER SIDE GATE AFTER
****  THE FIRST BOLT HAS CLEARED THE CONVEYER
 433  HOLD          126                          434          17
** BLOCK 433 DELAY ON CONVEYING SECOND BOLT IN ORDER TO GIVE THE
****  FIRST BOLT TIME TO CLEAR THE CONVEYER
 434  HOLD          127                          435          25
** BLOCK 434 SIMULATES TIME TO CONVEY  THE SECOND BOLT BACK TO THE
****  CONVEYER STOP
 435  HOLD          128                          436          5
** BLOCK 435 SIMULATES TIME TO STOP THE SECOND BOLT IN THE CONVEYER
 436  HOLD          129                          437          10
** BLOCK 436 SIMULATES TIME TO OPEN THE CONVEYER SIDE GATE FOR THE
****  SECOND BOLT
 437  HOLD          130                          438          5
** BLOCK 437 SIMULATES TIME FOR THE SECOND BOLT TO FALL OUT OF THE
****  CONVEYER
 438  HOLD          131                          445          10
** BLOCK 438 SIMULATES TIME TO CLOSE THE CONVEYER SIDE GATE AFTER
****  THE SECOND BOLT HAS CLEARED THE CONVEYER
 439  HOLD          132                          440          32
** BLOCK 439 DELAYS   CONVEYING THIRD BOLT IN ORDER TO GIVE THE
****  FIRST AND SECOND BOLTS TIME TO CLEAR THE CONVEYER
 440  HOLD          133                          441          50
** BLOCK 440 SIMULATES TIME TO CONVEY THE THIRD BOLT BACK TO THE
****  CONVEYER STOP
 441  HOLD          134                          442          5
** BLOCK 441 SIMULATES TIME TO STOP THE THIRD BOLT IN THE CONVEYER
 442  HOLD          135                          443          10
** BLOCK 442 SIMULATES TIME TO OPEN THE CONVEYER SIDE GATE FOR THE
****  THIRD BOLT
 443  HOLD          136                          444          5
** BLOCK 443 SIMULATES TIME FOR THE THIRD BOLT TO FALL OUT OF THE
****  CONVEYER
 444  HOLD          137                          445          10
** BLOCK 444 SIMULATES TIME TO CLOSE THE CONVEYER SIDE GATE AFTER
****  THE THIRD BOLT HAS CLEARED THE CONVEYER
 445  ASSEMBLE      3                            531
** BLOCK 445 HOLDS CONVEYER UNTIL ALL BOLT TRANSACTIONS HAVE COMPLETED
****  THEIR SIMULATIONS
 531  SAVEX        180   K0                     446
** BLOCK 531 SETS SAVEX 180 TO 0 TO CLEAR CONVEYER FOR NEW TREE
 446  HOLD          138                          447          10
** BLOCK 446 SIMULATES TIME TO ROTATE CONVEYER TO OTHER SIDE
 447  MATCH         449                          527
** BLOCK 447 HOLDS THE ORIGINAL TRANSACTION THAT SEIZED FACILITY
****  120 WHILE A DUPLICATE TRANSACTION SIMULATES A TREE BEING PROCESSED
****  THROUGH THE CONVEYER(THIS PROCEDURE IS A PROGRAMMING REQUIREMENT
****  TO INSURE THAT THE TRANSACTION THAT SEIZED FACILITY 120 ALSO
****  RELEASES IT)
 527  SAVEX        172   C1                     528
** BLOCK 527 (SAVEX 172) RECORDS TIME TREE IS AT BLOCK 527
 528  SAVEX        175   V26                    529
** BLOCK 528 (SAVEX 175) RECORDS ACTUAL OPERATING TIME OF CONVEYER
 529  SAVEX        179   V26                    530
** BLOCK 529 (SAVEX 179) RECORDS TIME TREE IS IN CONTROL OF CONVEYER
 530  PRINT         170   179                    448
** BLOCK 530 PRINTS PROCESS TIMES OF CONVEYER
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 448  TERMINATE
** BLOCK 448 TERMINATES THE DUPLICATE TREE TRANSACTION AFTER IT HAS
****  SIMULATED A TREE BEING PROCESSED THROUGH THE CONVEYER
 449  MATCH          447                      450
** BLOCK 449 HOLDS THE ORIGINAL TRANSACTION THAT SEIZED FACILITY
****  120 WHILE A DUPLICATE TRANSACTION SIMULATES A TREE BEING
****  PROCESSED THROUGH THE CONVEYER
 450  RELEASE        120                      451
** BLOCK 450 RELEASES FACILITY 120 (CONVEYER) AFTER A TREE TRANSACTION
****  PROCESSES THROUGH THE CONVEYER
 451  TERMINATE
** BLOCK 451 TERMINATES TREE TRANSACTIONS AFTER THEY HAVE BEEN
****  PROCESSED THROUGH THE SIMULATION PROGRAM
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*                SUBPROGRAM FOR PROGRAM TERMINATION
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 452  GENERATE     1     4                    453
** BLOCK 452 GENERATES TRANSACTION TO TERMINATE SIMULATION
 453  COMPARE      N76   G     K105           454
** BLOCK 453 HOLDS PROGRAM TERMINATION TRANSACTION UNTILL 105 TREE
****  TRANSACTIONS HAVE BEEN PROCESSED THROUGH THE SIMULATION
 454  ADVANCE                                 455          1800
** BLOCK 454 HOLDS PROGRAM TERMINATING TRANSACTION UNTIL TREE
**** TRANSACTION NUMBER 105 HAS HAD TIME TO PROCESS THROUGH THE
****  SIMULATION PROGRAM
 455  TERMINATE    R
** BLOCK 483 TERMINATES THE COMPLETE SIMULATION PROGRAM
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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*            END OF SIMULATION PROGRAM
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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      START        1
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SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	100	1	101	10	102	55	103	55	104	129
	105	129	106	0	107	0	108	0	109	129

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	110	1	111	10	112	55	113	119	114	119
	115	136	116	164	117	164	118	49	119	185
	120	181	121	0	122	185	123	195	124	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	130	1	131	10	132	109	133	127	134	164
	135	88	136	186	137	186	138	136	139	224
	140	201	141	0	142	201	143	234	144	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	100	2	101	139	102	184	103	195	104	279
	105	129	106	0	107	0	108	11	109	140

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	100	3	101	279	102	279	103	279	104	279
	105	0	106	1	107	0	108	0	109	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	150	1	151	10	152	201	153	289	154	289
	155	118	156	319	157	0	158	191	159	309

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	110	2	111	195	112	195	113	259	114	259
	115	136	116	304	117	304	118	4	119	140
	120	321	121	0	122	325	123	335	124	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	110	3	111	335	112	335	113	335	114	335
	115	0	116	335	117	335	118	0	119	0
	120	335	121	0	122	335	123	335	124	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	160	1	161	10	162	20	163	289	164	342
	165	73	166	342	167	352	168	269	169	342

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	130	2	131	234	132	249	133	268	134	304
	135	90	136	327	137	327	138	51	139	141
	140	342	141	0	142	342	143	375	144	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	150	2	151	319	152	342	153	430	154	430
	155	118	156	460	157	0	158	23	159	141

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	100	4	101	279	102	324	103	335	104	461
	105	171	106	0	107	0	108	11	109	182

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	170	1	171	352	172	474	173	0	174	0
	175	122	176	0	177	0	178	0	179	122

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	160	2	161	352	162	362	163	430	164	483
	165	73	166	483	167	493	168	68	169	141

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	110	4	111	335	112	335	113	441	114	441
	115	178	116	486	117	486	118	4	119	182
	120	503	121	0	122	507	123	517	124	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	130	4	131	375	132	431	133	449	134	486
	135	88	136	508	137	508	138	93	139	181
	140	523	141	0	142	523	143	556	144	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	100	5	101	461	102	506	103	517	104	603
	105	131	106	0	107	0	108	11	109	142

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	170	2	171	493	172	615	173	0	174	0
	175	122	176	0	177	0	178	0	179	122

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	150	4	151	460	152	523	153	611	154	611
	155	118	156	641	157	0	158	63	159	181

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	110	5	111	517	112	517	113	583	114	583
	115	138	116	628	117	628	118	4	119	142
	120	645	121	0	122	649	123	659	124	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	160	4	161	493	162	503	163	611	164	664
	165	73	166	664	167	674	168	108	169	181

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	130	5	131	556	132	573	133	592	134	628
	135	90	136	651	137	651	138	53	139	143
	140	666	141	0	142	666	143	699	144	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	100	6	101	603	102	638	103	659	104	744
	105	120	106	1111	107	0	108	21	109	141

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	150	5	151	641	152	666	153	754	154	754
	155	118	156	784	157	0	158	25	159	143

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	170	4	171	674	172	796	173	0	174	0
	175	122	176	0	177	0	178	0	179	122

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	110	6	111	659	112	659	113	724	114	724
	115	140	116	799	117	799	118	0	119	140
	120	799	121	1111	122	799	123	799	124	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	160	5	161	674	162	684	163	754	164	807
	165	73	166	807	167	817	168	70	169	143

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	100	7	101	744	102	789	103	799	104	884
	105	130	106	0	107	0	108	10	109	140

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	170	5	171	817	172	939	173	0	174	0
	175	122	176	0	177	0	178	0	179	122

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	110	7	111	799	112	799	113	864	114	864
	115	137	116	909	117	909	118	4	119	141
	120	926	121	0	122	930	123	940	124	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	130	7	131	744	132	744	133	765	134	909
	135	94	136	934	137	934	138	144	139	238
	140	949	141	0	142	949	143	982	144	0

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SAVEX  NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE
       100           8      101         884      102         929      103         940      104        1025
       105         130      106           0      107           0      108          11      109         141

SAVEX  NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE
       150           7      151         784      152         949      153        1037      154        1037
       155         118      156        1067      157           0      158         165      159         283

SAVEX  NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE
       110           8      111         940      112         940      113        1005      114        1005
       115         137      116        1050      117        1050      118           4      119         141
       120        1067      121           0      122        1071      123        1081      124           0

SAVEX  NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE
       160           7      161         817      162         827      163        1037      164        1090
       165          73      166        1090      167        1100      168         210      169         283

SAVEX  NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE
       130           8      131         982      132         995      133        1015      134        1050
       135          92      136        1074      137        1074      138          48      139         140
       140        1089      141           0      142        1089      143        1122      144           0

SAVEX  NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE
       100           9      101        1025      102        1070      103        1081      104        1163
       105         127      106           0      107           0      108          11      109         138

SAVEX  NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE
       150           8      151        1067      152        1089      153        1177      154        1177
       155         118      156        1207      157           0      158          22      159         140

SAVEX  NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE
       110           9      111        1081      112        1081      113        1143      114        1143
       115         134      116        1188      117        1188      118           4      119         138
       120        1205      121           0      122        1209      123        1219      124           0

SAVEX  NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE
       170           7      171        1100      172        1222      173           0      174           0
       175         122      176           0      177           0      178           0      179         122

SAVEX  NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE
       160           8      161        1100      162        1110      163        1177      164        1230
       165          73      166        1230      167        1240      168          87      169         140

SAVEX  NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE
       130           9      131        1122      132        1133      133        1151      134        1182
       135          88      136        1210      137        1210      138          48      139         136
       140        1225      141           0      142        1225      143        1258      144           0

SAVEX  NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE
       100          10      101        1163      102        1208      103        1219      104        1301
       105         127      106           0      107           0      108          11      109         138

SAVEX  NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE
       150           9      151        1207      152        1225      153        1313      154        1313
       155         118      156        1343      157           0      158          18      159         136

SAVEX  NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE     NR.........VALLE
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       110          10    111        1219    112        1219    113        1281    114        1281
       115         134    116        1326    117        1326    118           4    119         138
       120        1343    121           0    122        1347    123        1357    124           0

SAVEX  NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
       170           8    171        1240    172        1362    173           0    174           0
       175         122    176           0    177           0    178           0    179         122

SAVEX  NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
       160           9    161        1240    162        1250    163        1313    164        1366
       165          73    166        1366    167        1376    168          63    169         138

SAVEX  NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
       130          10    131        1258    132        1271    133        1289    134        1326
       135          88    136        1348    137        1348    138          50    139         138
       140        1363    141           0    142        1363    143        1396    144           0

SAVEX  NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
       100          11    101        1301    102        1346    103        1357    104        1440
       105         128    106           0    107           0    108          11    109         139

SAVEX  NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
       150          10    151        1343    152        1363    153        1451    154        1451
       155         118    156        1481    157           0    158          20    159         138

SAVEX  NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
       110          11    111        1357    112        1357    113        1420    114        1420
       115         135    116        1465    117        1465    118           4    119         139
       120        1482    121           0    122        1486    123        1496    124           0

SAVEX  NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
       170           9    171        1376    172        1498    173           0    174           0
       175         122    176           0    177           0    178           0    179         122

SAVEX  NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
       160          10    161        1376    162        1386    163        1451    164        1504
       165          73    166        1504    167        1514    168          65    169         138

SAVEX  NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
       130          11    131        1396    132        1410    133        1428    134        1465
       135          88    136        1487    137        1487    138          51    139         139
       140        1502    141           0    142        1502    143        1535    144           0

SAVEX  NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
       100          12    101        1440    102        1485    103        1496    104        1580
       105         129    106           0    107           0    108          11    109         140

SAVEX  NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
       150          11    151        1481    152        1502    153        1590    154        1590
       155         118    156        1620    157           0    158          21    159         139

SAVEX  NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
       170          10    171        1514    172        1636    173           0    174           0
       175         122    176           0    177           0    178           0    179         122

SAVEX  NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
       110          12    111        1496    112        1496    113        1560    114        1560
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         115          136    116         1605    117         1605    118            4    119          140
         120         1622    121            0    122         1626    123         1636    124            0

SAVEX  NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE
         160           11    161         1514    162         1524    163         1590    164         1643
         165           73    166         1643    167         1653    168           66    169          139

SAVEX  NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE
         130           12    131         1535    132         1550    133         1569    134         1605
         135           90    136         1628    137         1628    138           51    139          141
         140         1643    141            0    142         1643    143         1676    144            0

SAVEX  NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE
         100           13    101         1580    102         1625    103         1636    104         1719
         105          128    106            0    107            0    108           11    109          139

SAVEX  NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE
         150           12    151         1620    152         1643    153         1731    154         1731
         155          118    156         1761    157            0    158           23    159          141

SAVEX  NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE
         170           11    171         1653    172         1775    173            0    174            0
         175          122    176            0    177            0    178            0    179          122

SAVEX  NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE
         110           13    111         1636    112         1636    113         1699    114         1699
         115          135    116         1744    117         1744    118            4    119          139
         120         1761    121            0    122         1765    123         1775    124            0

SAVEX  NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE
         160           12    161         1653    162         1663    163         1731    164         1784
         165           73    166         1784    167         1794    168           68    169          141

SAVEX  NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE
         130           13    131         1676    132         1689    133         1707    134         1744
         135           88    136         1766    137         1766    138           50    139          138
         140         1781    141            0    142         1781    143         1814    144            0

SAVEX  NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE
         100           14    101         1719    102         1764    103         1775    104         1857
         105          127    106            0    107            0    108           11    109          138

SAVEX  NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE
         100           15    101         1857    102         1857    103         1857    104         1857
         105            0    106            1    107            0    108            0    109            0

SAVEX  NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE
         100           16    101         1857    102         1857    103         1857    104         1857
         105            0    106            1    107            0    108            0    109            0

SAVEX  NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE
         150           13    151         1761    152         1781    153         1869    154         1869
         155          118    156         1899    157            0    158           20    159          138

SAVEX  NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE
         110           14    111         1775    112         1775    113         1837    114         1837
         115          134    116         1882    117         1882    118            4    119          138
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        120        1899    121          0    122        1903    123        1913    124           0

SAVEX   NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
        110          15    111       1913    112        1913    113        1913    114        1913
        115           0    116       1913    117        1913    118           0    119           0
        120        1913    121          0    122        1913    123        1913    124           0

SAVEX   NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
        110          16    111       1913    112        1913    113        1913    114        1913
        115           0    116       1913    117        1913    118           0    119           0
        120        1913    121          0    122        1913    123        1913    124           0

SAVEX   NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
        170          12    171       1794    172        1916    173           0    174           0
        175         122    176          0    177           0    178           0    179         122

SAVEX   NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
        160          13    161       1794    162        1804    163        1869    164        1922
        165          73    166       1922    167        1932    168          65    169         138

SAVEX   NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
        130          14    131       1814    132        1827    133        1846    134        1882
        135          90    136       1905    137        1905    138          49    139         139
        140        1920    141          0    142        1920    143        1953    144           0

SAVEX   NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
        150          14    151       1899    152        1920    153        2008    154        2008
        155         118    156       2038    157           0    158          21    159         139

SAVEX   NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
        170          13    171       1932    172        2054    173           0    174           0
        175         122    176          0    177           0    178           0    179         122

SAVEX   NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
        160          14    161       1932    162        1942    163        2008    164        2061
        165          73    166       2061    167        2071    168          66    169         139

SAVEX   NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
        100          17    101       1857    102        1902    103        1913    104        2081
        105         213    106          0    107           0    108          11    109         224

SAVEX   NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
        100          18    101       2081    102        2081    103        2081    104        2081
        105           0    106          1    107           0    108           0    109           0

SAVEX   NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
        110          17    111       1913    112        1913    113        2061    114        2061
        115         220    116       2106    117        2106    118           4    119         224
        120        2123    121          0    122        2127    123        2137    124           0

SAVEX   NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
        110          18    111       2137    112        2137    113        2137    114        2137
        115           0    116       2137    117        2137    118           0    119           0
        120        2137    121          0    122        2137    123        2137    124           0

SAVEX   NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
        130          17    131       1953    132        2051    133        2069    134        2106
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	135	88	136	2128	137	2128	138	135	139	223
	140	2143	141	0	142	2143	143	2176	144	0
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	170	14	171	2071	172	2193	173	0	174	0
	175	122	176	0	177	0	178	0	179	122
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	150	17	151	2038	152	2143	153	2231	154	2231
	155	118	156	2261	157	0	158	105	159	223
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	100	19	101	2081	102	2126	103	2137	104	2264
	105	172	106	0	107	0	108	11	109	183
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	160	17	161	2071	162	2081	163	2231	164	2284
	165	73	166	2284	167	2294	168	150	169	223
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	110	19	111	2137	112	2137	113	2244	114	2244
	115	179	116	2289	117	2289	118	4	119	183
	120	2306	121	0	122	2310	123	2320	124	0
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	130	19	131	2176	132	2234	133	2252	134	2289
	135	88	136	2311	137	2311	138	95	139	183
	140	2326	141	0	142	2326	143	2359	144	0
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	100	20	101	2264	102	2309	103	2320	104	2405
	105	130	106	0	107	0	108	11	109	141
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	170	17	171	2294	172	2416	173	0	174	0
	175	122	176	0	177	0	178	0	179	122
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	150	19	151	2261	152	2326	153	2414	154	2414
	155	118	156	2444	157	0	158	65	159	183
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	110	20	111	2320	112	2320	113	2385	114	2385
	115	137	116	2430	117	2430	118	4	119	141
	120	2447	121	0	122	2451	123	2461	124	0
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	160	19	161	2294	162	2304	163	2414	164	2467
	165	73	166	2467	167	2477	168	110	169	183
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	130	20	131	2359	132	2375	133	2396	134	2430
	135	94	136	2455	137	2455	138	50	139	144
	140	2470	141	0	142	2470	143	2503	144	0
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	100	21	101	2405	102	2450	103	2461	104	2543

	105	127	106	0	107	0	108	11	109	138
SAVEX	NR.........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	150	20	151	2444	152	2470	153	2558	154	2558
	155	118	156	2588	157	0	158	26	159	144
SAVEX	NR.........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	170	19	171	2477	172	2599	173	0	174	0
	175	122	176	0	177	0	178	0	179	122
SAVEX	NR.........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	110	21	111	2461	112	2461	113	2523	114	2523
	115	134	116	2568	117	2568	118	4	119	138
	120	2585	121	0	122	2589	123	2599	124	0
SAVEX	NR.........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	160	20	161	2477	162	2487	163	2558	164	2611
	165	73	166	2611	167	2621	168	71	169	144
SAVEX	NR.........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	130	21	131	2503	132	2513	133	2531	134	2568
	135	88	136	2590	137	2590	138	47	139	135
	140	2605	141	0	142	2605	143	2638	144	0
SAVEX	NR.........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	100	22	101	2543	102	2588	103	2599	104	2666
	105	132	106	0	107	0	108	11	109	143
SAVEX	NR.........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	150	21	151	2588	152	2609	153	2693	154	2693
	155	118	156	2723	157	0	158	17	159	135
SAVEX	NR.........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	110	22	111	2599	112	2599	113	2666	114	2666
	115	139	116	2711	117	2711	118	4	119	143
	120	2728	121	0	122	2732	123	2742	124	0
SAVEX	NR.........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	170	20	171	2621	172	2743	173	0	174	0
	175	122	176	0	177	0	178	0	179	122
SAVEX	NR.........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	160	21	161	2621	162	2631	163	2693	164	2746
	165	73	166	2746	167	2756	168	62	169	135
SAVEX	NR.........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	130	22	131	2638	132	2656	133	2674	134	2711
	135	88	136	2733	137	2733	138	55	139	143
	140	2748	141	0	142	2748	143	2781	144	0
SAVEX	NR.........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	100	23	101	2686	102	2731	103	2742	104	2828
	105	131	106	0	107	0	108	11	109	142
SAVEX	NR.........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	150	22	151	2723	152	2748	153	2836	154	2836
	155	118	156	2866	157	0	158	25	159	143

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	170	21	171	2756	172	2878	173	0	174	0
	175	122	176	0	177	0	178	0	179	122

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	110	23	111	2742	112	2742	113	2808	114	2808
	115	138	116	2853	117	2853	118	4	119	142
	120	2870	121	0	122	2874	123	2884	124	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	160	22	161	2756	162	2766	163	2836	164	2889
	165	73	166	2889	167	2899	168	70	169	143

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	130	23	131	2781	132	2798	133	2820	134	2853
	135	96	136	2879	137	2879	138	50	139	146
	140	2894	141	0	142	2894	143	2927	144	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	100	24	101	2828	102	2873	103	2884	104	2967
	105	128	106	0	107	0	108	11	109	139

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	150	23	151	2866	152	2894	153	2982	154	2982
	155	118	156	3012	157	0	158	28	159	146

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	170	22	171	2899	172	3021	173	0	174	0
	175	122	176	0	177	0	178	0	179	122

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	110	24	111	2884	112	2884	113	2947	114	2947
	115	135	116	2992	117	2992	118	4	119	139
	120	3009	121	0	122	3013	123	3023	124	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	160	23	161	2899	162	2909	163	2982	164	3035
	165	73	166	3035	167	3045	168	73	169	146

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	130	24	131	2927	132	2937	133	2955	134	2992
	135	88	136	3014	137	3014	138	47	139	135
	140	3029	141	0	142	3029	143	3062	144	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	100	25	101	2967	102	3012	103	3023	104	3108
	105	130	106	0	107	0	108	11	109	141

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	100	26	101	3108	102	3108	103	3108	104	3108
	105	0	106	1	107	0	108	0	109	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	150	24	151	3012	152	3029	153	3117	154	3117
	155	118	156	3147	157	0	158	17	159	135

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE

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       110          25     111        3023     112        3023     113        3066     114        3088
       115         137     116        3133     117        3133     118           4     119         141
       120        3150     121           0     122        3154     123        3164     124           0

SAVEX  NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE
       110          26     111        3164     112        3164     113        3164     114        3164
       115           0     116        3164     117        3164     118           0     119           0
       120        3164     121           0     122        3164     123        3164     124           0

SAVEX  NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE
       170          23     171        3045     172        3167     173           0     174           0
       175         122     176           0     177           0     178           0     179         122

SAVEX  NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE
       160          24     161        3045     162        3055     163        3117     164        3170
       165          73     166        3170     167        3180     168          62     169         135

SAVEX  NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE
       130          25     131        3062     132        3078     133        3056     134        3133
       135          88     136        3155     137        3155     138          53     139         141
       140        3170     141           0     142        3170     143        3203     144           0

SAVEX  NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE
       150          25     151        3147     152        3170     153        3258     154        3258
       155         118     156        3288     157           0     158          23     159         141

SAVEX  NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE
       100          27     101        3108     102        3153     103        3164     104        3292
       105         173     106           0     107           0     108          11     109         184

SAVEX  NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE
       170          24     171        3180     172        3302     173           0     174           0
       175         122     176           0     177           0     178           0     179         122

SAVEX  NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE
       160          25     161        3180     162        3190     163        3258     164        3311
       165          73     166        3311     167        3321     168          68     169         141

SAVEX  NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE
       110          27     111        3164     112        3164     113        3272     114        3272
       115         180     116        3317     117        3317     118           4     119         184
       120        3334     121           0     122        3338     123        3348     124           0

SAVEX  NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE
       130          27     131        3203     132        3262     133        3284     134        3317
       135          96     136        3343     137        3343     138          92     139         188
       140        3358     141           0     142        3358     143        3391     144           0

SAVEX  NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE
       100          28     101        3292     102        3337     103        3348     104        3433
       105         130     106           0     107           0     108          11     109         141

SAVEX  NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE
       170          25     171        3321     172        3443     173           0     174           0
       175         122     176           0     177           0     178           0     179         122

SAVEX  NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE
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        150          27    151        3288    152        3358    153        3446    154        3446
        155         118    156        3476    157           0    158          70    159         166

SAVEX   NR.........VALUE   NR.........VALUE   NR.........VALUE   NR.........VALUE   NR.........VALUE
        110          28    111        3348    112        3348    113        3413    114        3413
        115         137    116        3458    117        3458    118           4    119         141
        120        3475    121           0    122        3479    123        3489    124           0

SAVEX   NR.........VALUE   NR.........VALUE   NR.........VALUE   NR.........VALUE   NR.........VALUE
        160          27    161        3321    162        3331    163        3446    164        3499
        165          73    166        3499    167        3509    168         115    169         186

SAVEX   NR.........VALUE   NR.........VALUE   NR.........VALUE   NR.........VALUE   NR.........VALUE
        130          28    131        3391    132        3403    133        3421    134        3456
        135          88    136        3480    137        3480    138          49    139         137
        140        3495    141           0    142        3495    143        3528    144           0

SAVEX   NR.........VALUE   NR.........VALUE   NR.........VALUE   NR.........VALUE   NR.........VALUE
        100          29    101        3433    102        3478    103        3489    104        3572
        105         128    106           0    107           0    108          11    109         139

SAVEX   NR.........VALUE   NR.........VALUE   NR.........VALUE   NR.........VALUE   NR.........VALUE
        150          28    151        3476    152        3495    153        3583    154        3583
        155         118    156        3613    157           0    158          19    159         137

SAVEX   NR.........VALUE   NR.........VALUE   NR.........VALUE   NR.........VALUE   NR.........VALUE
        110          29    111        3489    112        3489    113        3552    114        3552
        115         135    116        3597    117        3597    118           4    119         139
        120        3614    121           0    122        3618    123        3628    124           0

SAVEX   NR.........VALUE   NR.........VALUE   NR.........VALUE   NR.........VALUE   NR.........VALUE
        170          27    171        3509    172        3631    173           0    174           0
        175         122    176           0    177           0    178           0    179         122

SAVEX   NR.........VALUE   NR.........VALUE   NR.........VALUE   NR.........VALUE   NR.........VALUE
        160          28    161        3509    162        3519    163        3583    164        3636
        165          73    166        3636    167        3646    168          64    169         137

SAVEX   NR.........VALUE   NR.........VALUE   NR.........VALUE   NR.........VALUE   NR.........VALUE
        130          29    131        3528    132        3542    133        3562    134        3597
        135          92    136        3621    137        3621    138          49    139         141
        140        3636    141           0    142        3636    143        3669    144           0

SAVEX   NR.........VALUE   NR.........VALUE   NR.........VALUE   NR.........VALUE   NR.........VALUE
        100          30    101        3572    102        3617    103        3628    104        3718
        105         135    106           0    107           0    108          11    109         146

SAVEX   NR.........VALUE   NR.........VALUE   NR.........VALUE   NR.........VALUE   NR.........VALUE
        150          29    151        3613    152        3636    153        3724    154        3724
        155         118    156        3754    157           0    158          23    159         141

SAVEX   NR.........VALUE   NR.........VALUE   NR.........VALUE   NR.........VALUE   NR.........VALUE
        170          28    171        3646    172        3768    173           0    174           0
        175         122    176           0    177           0    178           0    179         122

SAVEX   NR.........VALUE   NR.........VALUE   NR.........VALUE   NR.........VALUE   NR.........VALUE
        110          30    111        3628    112        3628    113        3698    114        3696
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	115	142	116	3743	117	3743	118	4	119	146
	120	3760	121	0	122	3764	123	3774	124	0
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	160	29	161	3646	162	3656	163	3724	164	3777
	165	73	166	3777	167	3787	168	68	169	141
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	130	30	131	3669	132	3688	133	3709	134	3743
	135	94	136	3768	137	3768	138	53	139	147
	140	3783	141	0	142	3783	143	3816	144	0
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	100	31	101	3718	102	3763	103	3774	104	3862
	105	133	106	0	107	0	108	11	109	144
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	150	30	151	3754	152	3783	153	3871	154	3871
	155	118	156	3901	157	0	158	29	159	147
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	170	29	171	3787	172	3909	173	0	174	0
	175	122	176	0	177	0	178	0	179	122
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	110	31	111	3774	112	3774	113	3842	114	3842
	115	140	116	3887	117	3887	118	4	119	144
	120	3904	121	0	122	3908	123	3918	124	0
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	160	30	161	3787	162	3797	163	3871	164	3924
	165	73	166	3924	167	3934	168	74	169	147
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	130	31	131	3816	132	3832	133	3854	134	3887
	135	96	136	3913	137	3913	138	49	139	145
	140	3928	141	0	142	3928	143	3961	144	0
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	100	32	101	3862	102	3907	103	3918	104	4001
	105	128	106	0	107	0	108	11	109	139
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	150	31	151	3901	152	3928	153	4016	154	4016
	155	118	156	4046	157	0	158	27	159	145
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	170	30	171	3934	172	4056	173	0	174	0
	175	122	176	0	177	0	178	0	179	122
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	110	32	111	3918	112	3918	113	3981	114	3981
	115	135	116	4026	117	4026	118	4	119	139
	120	4043	121	0	122	4047	123	4057	124	0
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	160	31	161	3934	162	3944	163	4016	164	4069

	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	165	73	166	4069	167	4079	168	72	169	143
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	130	32	131	3961	132	3971	133	3990	134	4026
	135	90	136	4049	137	4049	138	46	139	136
	140	4064	141	0	142	4064	143	4097	144	0
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	100	33	101	4061	102	4046	103	4057	104	4140
	105	128	106	0	107	0	108	11	109	139
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	150	32	151	4046	152	4064	153	4152	154	4152
	155	118	156	4182	157	0	158	18	159	136
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	110	33	111	4057	112	4057	113	4120	114	4120
	115	135	116	4165	117	4165	118	4	119	139
	120	4182	121	0	122	4186	123	4196	124	0
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	170	31	171	4079	172	4201	173	0	174	0
	175	122	176	0	177	0	178	0	179	122
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	160	32	161	4079	162	4089	163	4152	164	4205
	165	73	166	4205	167	4215	168	63	169	136
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	130	33	131	4097	132	4110	133	4128	134	4165
	135	88	136	4187	137	4187	138	50	139	138
	140	4202	141	0	142	4202	143	4235	144	0
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	100	34	101	4140	102	4185	103	4196	104	4279
	105	128	106	0	107	0	108	11	109	139
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	100	35	101	4279	102	4279	103	4279	104	4279
	105	0	106	1	107	0	108	0	109	0
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	150	33	151	4182	152	4202	153	4290	154	4290
	155	118	156	4320	157	0	158	20	159	138
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	110	34	111	4196	112	4196	113	4259	114	4259
	115	135	116	4304	117	4304	118	4	119	139
	120	4321	121	0	122	4325	123	4335	124	0
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	110	35	111	4335	112	4335	113	4335	114	4335
	115	0	116	4335	117	4335	118	0	119	0
	120	4335	121	0	122	4335	123	4335	124	0
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	170	32	171	4215	172	4337	173	0	174	0

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      175        122   176          0   177          0   178          0   179        122

SAVEX NR........VALUE  NR........VALUE  NR........VALUE  NR........VALUE  NR........VALUE
      160         33   161       4215   162       4225   163       4290   164       4343
      165         73   166       4343   167       4353   168         65   169        136

SAVEX NR........VALUE  NR........VALUE  NR........VALUE  NR........VALUE  NR........VALUE
      130         34   131       4235   132       4249   133       4268   134       4304
      135         90   136       4327   137       4327   138         50   139        140
      140       4342   141          0   142       4342   143       4375   144          0

SAVEX NR........VALUE  NR........VALUE  NR........VALUE  NR........VALUE  NR........VALUE
      150         34   151       4320   152       4342   153       4430   154       4430
      155        118   156       4460   157          0   158         22   159        140

SAVEX NR........VALUE  NR........VALUE  NR........VALUE  NR........VALUE  NR........VALUE
      100         36   101       4279   102       4324   103       4335   104       4461
      105        171   106          0   107          0   108         11   109        182

SAVEX NR........VALUE  NR........VALUE  NR........VALUE  NR........VALUE  NR........VALUE
      170         33   171       4353   172       4475   173          0   174          0
      175        122   176          0   177          0   178          0   179        122

SAVEX NR........VALUE  NR........VALUE  NR........VALUE  NR........VALUE  NR........VALUE
      160         34   161       4353   162       4363   163       4430   164       4483
      165         73   166       4483   167       4493   168         67   169        140

SAVEX NR........VALUE  NR........VALUE  NR........VALUE  NR........VALUE  NR........VALUE
      110         36   111       4335   112       4335   113       4441   114       4441
      115        178   116       4486   117       4486   118          4   119        182
      120       4503   121          0   122       4507   123       4517   124          0

SAVEX NR........VALUE  NR........VALUE  NR........VALUE  NR........VALUE  NR........VALUE
      130         36   131       4375   132       4431   133       4449   134       4486
      135         88   136       4508   137       4508   138         93   139        181
      140       4523   141          0   142       4523   143       4556   144          0

SAVEX NR........VALUE  NR........VALUE  NR........VALUE  NR........VALUE  NR........VALUE
      100         37   101       4461   102       4506   103       4517   104       4603
      105        131   106          0   107          0   108         11   109        142

SAVEX NR........VALUE  NR........VALUE  NR........VALUE  NR........VALUE  NR........VALUE
      170         34   171       4493   172       4615   173          0   174          0
      175        122   176          0   177          0   178          0   179        122

SAVEX NR........VALUE  NR........VALUE  NR........VALUE  NR........VALUE  NR........VALUE
      150         36   151       4460   152       4523   153       4611   154       4611
      155        118   156       4641   157          0   158         63   159        181

SAVEX NR........VALUE  NR........VALUE  NR........VALUE  NR........VALUE  NR........VALUE
      110         37   111       4517   112       4517   113       4583   114       4583
      115        138   116       4628   117       4628   118          4   119        142
      120       4645   121          0   122       4649   123       4659   124          0

SAVEX NR........VALUE  NR........VALUE  NR........VALUE  NR........VALUE  NR........VALUE
      160         36   161       4493   162       4503   163       4611   164       4664
      165         73   166       4664   167       4674   168        108   169        181
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SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	130	37	131	4556	132	4573	133	4592	134	4628
	135	90	136	4651	137	4651	138	53	139	143
	140	4666	141	0	142	4666	143	4695	144	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	100	38	101	4603	102	4648	103	4659	104	4743
	105	129	106	0	107	0	108	11	109	140

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	150	37	151	4641	152	4666	153	4754	154	4754
	155	118	156	4784	157	0	158	25	159	143

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	170	36	171	4674	172	4796	173	0	174	0
	175	122	176	0	177	0	178	0	179	122

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	110	38	111	4659	112	4659	113	4723	114	4723
	115	136	116	4768	117	4768	118	4	119	140
	120	4785	121	0	122	4789	123	4799	124	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	160	37	161	4674	162	4684	163	4754	164	4807
	165	73	166	4807	167	4817	168	70	169	143

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	130	38	131	4699	132	4713	133	4733	134	4768
	135	92	136	4792	137	4792	138	49	139	141
	140	4807	141	0	142	4807	143	4840	144	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	100	39	101	4743	102	4778	103	4799	104	4885
	105	121	106	1111	107	0	108	21	109	142

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	100	40	101	4885	102	4885	103	4885	104	4885
	105	0	106	1	107	0	108	0	109	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	150	38	151	4784	152	4807	153	4895	154	4895
	155	118	156	4925	157	0	158	23	159	141

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	170	37	171	4817	172	4939	173	0	174	0
	175	122	176	0	177	0	178	0	179	122

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	110	39	111	4799	112	4799	113	4865	114	4865
	115	141	116	4940	117	4940	118	0	119	141
	120	4940	121	1111	122	4940	123	4940	124	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	110	40	111	4940	112	4940	113	4940	114	4940
	115	0	116	4940	117	4940	118	0	119	0
	120	4940	121	0	122	4940	123	4940	124	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	160	38	161	4817	162	4827	163	4895	164	4948
	165	73	166	4948	167	4958	168	68	169	141

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	100	41	101	4885	102	4930	103	4940	104	5070
	105	175	106	0	107	0	108	10	109	185

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	100	42	101	5070	102	5070	103	5070	104	5070
	105	0	106	1	107	0	108	0	109	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	170	38	171	4958	172	5080	173	0	174	0
	175	122	176	0	177	0	178	0	179	122

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	110	41	111	4940	112	4940	113	5050	114	5050
	115	182	116	5095	117	5095	118	4	119	186
	120	5112	121	0	122	5116	123	5126	124	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	110	42	111	5126	112	5126	113	5126	114	5126
	115	0	116	5126	117	5126	118	0	119	0
	120	5126	121	0	122	5126	123	5126	124	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	130	41	131	4885	132	4885	133	4903	134	5095
	135	88	136	5117	137	5117	138	192	139	280
	140	5132	141	0	142	5132	143	5165	144	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	150	41	151	4925	152	5132	153	5220	154	5220
	155	118	156	5250	157	0	158	207	159	325

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	100	43	101	5070	102	5115	103	5126	104	5251
	105	170	106	0	107	0	108	11	109	181

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	160	41	161	4958	162	4968	163	5220	164	5273
	165	73	166	5273	167	5283	168	252	169	325

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	110	43	111	5126	112	5126	113	5231	114	5231
	115	177	116	5276	117	5276	118	4	119	181
	120	5293	121	0	122	5297	123	5307	124	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	130	43	131	5165	132	5221	133	5240	134	5276
	135	90	136	5299	137	5299	138	92	139	182
	140	5314	141	0	142	5314	143	5347	144	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	100	44	101	5251	102	5296	103	5307	104	5394
	105	132	106	0	107	0	108	11	109	143

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	170	41	171	5283	172	5405	173	0	174	0
	175	122	176	0	177	0	178	0	179	122

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	150	43	151	5250	152	5314	153	5402	154	5402
	155	118	156	5432	157	0	158	64	159	182

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	110	44	111	5307	112	5307	113	5374	114	5374
	115	139	116	5419	117	5419	118	4	119	143
	120	5436	121	0	122	5440	123	5450	124	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	160	43	161	5283	162	5293	163	5402	164	5455
	165	73	166	5465	167	5465	168	109	169	182

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	130	44	131	5347	132	5364	133	5382	134	5419
	135	88	136	5441	137	5441	138	54	139	142
	140	5456	141	0	142	5456	143	5489	144	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	100	45	101	5394	102	5439	103	5450	104	5539
	105	134	106	0	107	0	108	11	109	145

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	150	44	151	5432	152	5456	153	5544	154	5544
	155	118	156	5574	157	0	158	24	159	142

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	170	43	171	5465	172	5587	173	0	174	0
	175	122	176	0	177	0	178	0	179	122

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	110	45	111	5450	112	5450	113	5519	114	5519
	115	141	116	5564	117	5564	118	4	119	145
	120	5581	121	0	122	5585	123	5595	124	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	160	44	161	5465	162	5475	163	5544	164	5597
	165	73	166	5597	167	5607	168	69	169	142

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	130	45	131	5489	132	5509	133	5531	134	5564
	135	96	136	5590	137	5590	138	53	139	149
	140	5605	141	0	142	5605	143	5638	144	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	100	46	101	5539	102	5584	103	5595	104	5679
	105	129	106	0	107	0	108	11	109	140

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	100	47	101	5679	102	5679	103	5679	104	5679
	105	0	106	1	107	0	108	0	109	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE

	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	150	45	151	5574	152	5605	153	5693	154	5693
	155	118	156	5723	157	0	158	31	159	149
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	170	44	171	5607	172	5729	173	0	174	0
	175	122	176	0	177	0	178	0	179	122
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	110	46	111	5595	112	5595	113	5659	114	5659
	115	136	116	5704	117	5704	118	4	119	140
	120	5721	121	0	122	5725	123	5735	124	0
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	110	47	111	5735	112	5735	113	5735	114	5735
	115	0	116	5735	117	5735	118	0	119	0
	120	5735	121	0	122	5735	123	5735	124	0
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	160	45	161	5607	162	5617	163	5693	164	5748
	165	73	166	5746	167	5756	168	76	169	149
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	130	46	131	5638	132	5649	133	5669	134	5704
	135	92	136	5728	137	5728	138	46	139	138
	140	5743	141	0	142	5743	143	5776	144	0
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	100	48	101	5679	102	5724	103	5735	104	5860
	105	170	106	0	107	0	108	11	109	181
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	150	46	151	5723	152	5743	153	5831	154	5831
	155	118	156	5861	157	0	158	20	159	132
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	170	45	171	5756	172	5878	173	0	174	0
	175	122	176	0	177	0	178	0	179	122
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	160	46	161	5756	162	5766	163	5831	164	5884
	165	73	166	5884	167	5894	168	65	169	138
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	110	48	111	5735	112	5735	113	5840	114	5840
	115	177	116	5885	117	5885	118	4	119	181
	120	5902	121	0	122	5906	123	5916	124	0
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	130	48	131	5776	132	5830	133	5848	134	5885
	135	88	136	5907	137	5907	138	91	139	179
	140	5922	141	0	142	5922	143	5955	144	0
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	100	49	101	5860	102	5905	103	5916	104	5999
	105	128	106	0	107	0	108	11	109	139
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE

	170	48	171	5894	172	6016	173	0	174	0
	175	122	176	0	177	0	178	0	179	122
SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	150	48	151	5861	152	5922	153	6010	154	6010
	155	118	156	6040	157	0	158	61	159	179
SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	110	49	111	5916	112	5916	113	5979	114	5979
	115	135	116	6024	117	6024	118	4	119	139
	120	6041	121	0	122	6045	123	6055	124	0
SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	160	48	161	5894	162	5904	163	6010	164	6063
	165	73	166	6063	167	6073	168	106	169	179
SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	130	49	131	5955	132	5969	133	5987	134	6024
	135	88	136	6046	137	6046	138	51	139	139
	140	6061	141	0	142	6061	143	6094	144	0
SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	100	50	101	5999	102	6044	103	6055	104	6139
	105	129	106	0	107	0	108	11	109	140
SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	100	51	101	6139	102	6139	103	6139	104	6139
	105	0	106	1	107	0	108	0	109	0
SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	150	49	151	6040	152	6061	153	6149	154	6149
	155	118	156	6179	157	0	158	21	159	139
SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	170	48	171	6073	172	6195	173	0	174	0
	175	122	176	0	177	0	178	0	179	122
SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	110	50	111	6055	112	6055	113	6119	114	6119
	115	136	116	6164	117	6164	118	4	119	140
	120	6181	121	0	122	6185	123	6195	124	0
SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	110	51	111	6195	112	6195	113	6195	114	6195
	115	0	116	6195	117	6195	118	0	119	0
	120	6195	121	0	122	6195	123	6195	124	0
SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	160	49	161	6073	162	6083	163	6149	164	6202
	165	73	166	6202	167	6212	168	66	169	139
SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	130	50	131	6094	132	6109	133	6128	134	6164
	135	90	136	6187	137	6187	138	51	139	141
	140	6202	141	0	142	6202	143	6235	144	0
SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE

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         150           50    151        6179    152          6202    153          6290    154          6290
         155          118    156        6320    157             0    158            23    159           141

SAVEX    NR........VALLE     NR........VALLE    NR........VALLE      NR........VALLE     NR........VALLE
         100           52    101        6139    102          6184    103          6195    104          6324
         105          174    106           0    107             0    108            11    109           185

SAVEX    NR........VALLE     NR........VALLE    NR........VALLE      NR........VALLE     NR........VALLE
         170           49    171        6212    172          6334    173             0    174             0
         175          122    176           0    177             0    178             0    179           122

SAVEX    NR........VALLE     NR........VALLE    NR........VALLE      NR........VALLE     NR........VALLE
         160           50    161        6212    162          6222    163          6290    164          6343
         165           73    166        6343    167          6353    168            68    169           141

SAVEX    NR........VALLE     NR........VALLE    NR........VALLE      NR........VALLE     NR........VALLE
         110           52    111        6195    112          6195    113          6304    114          6304
         115          181    116        6349    117          6349    118             4    119           185
         120         6366    121           0    122          6370    123          6380    124             0

SAVEX    NR........VALLE     NR........VALLE    NR........VALLE      NR........VALLE     NR........VALLE
         130           52    131        6235    132          6294    133          6312    134          6349
         135           88    136        6371    137          6371    138            96    139           184
         140         6386    141           0    142          6386    143          6419    144             0

SAVEX    NR........VALLE     NR........VALLE    NR........VALLE      NR........VALLE     NR........VALLE
         100           53    101        6324    102          6369    103          6380    104          6467
         105          132    106           0    107             0    108            11    109           142

SAVEX    NR........VALLE     NR........VALLE    NR........VALLE      NR........VALLE     NR........VALLE
         100           54    101        6467    102          6467    103          6467    104          6467
         105            0    106           1    107             0    108             0    109             0

SAVEX    NR........VALLE     NR........VALLE    NR........VALLE      NR........VALLE     NR........VALLE
         170           50    171        6353    172          6475    173             0    174             0
         175          122    176           0    177             0    178             0    179           122

SAVEX    NR........VALLE     NR........VALLE    NR........VALLE      NR........VALLE     NR........VALLE
         150           52    151        6320    152          6386    153          6474    154          6474
         155          118    156        6504    157             0    158            66    159           184

SAVEX    NR........VALLE     NR........VALLE    NR........VALLE      NR........VALLE     NR........VALLE
         110           53    111        6380    112          6380    113          6447    114          6447
         115          139    116        6492    117          6492    118             4    119           143
         120         6509    121           0    122          6513    123          6523    124             0

SAVEX    NR........VALLE     NR........VALLE    NR........VALLE      NR........VALLE     NR........VALLE
         110           54    111        6523    112          6523    113          6523    114          6523
         115            0    116        6523    117          6523    118             0    119             0
         120         6523    121           0    122          6523    123          6523    124             0

SAVEX    NR........VALLE     NR........VALLE    NR........VALLE      NR........VALLE     NR........VALLE
         160           52    161        6353    162          6363    163          6474    164          6527
         165           73    166        6527    167          6537    168           111    169           184

SAVEX    NR........VALLE     NR........VALLE    NR........VALLE      NR........VALLE     NR........VALLE
         130           53    131        6419    132          6437    133          6459    134          6492
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     135        96    136      6518    137      6518    138        51    139       147
     140      6533    141         0    142      6533    143      6566    144         0

SAVEX NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
     100        55    101      6467    102      6512    103      6523    104      6648
     105       170    106         0    107         0    108        11    109       181

SAVEX NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
     150        53    151      6504    152      6533    153      6621    154      6621
     155       118    156      6651    157         0    158        29    159       147

SAVEX NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
     170        52    171      6537    172      6659    173         0    174         0
     175       122    176         0    177         0    178         0    179       122

SAVEX NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
     160        53    161      6537    162      6547    163      6621    164      6674
     165        73    166      6674    167      6684    168        74    169       147

SAVEX NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
     110        55    111      6523    112      6523    113      6628    114      6628
     115       177    116      6673    117      6673    118         4    119       181
     120      6690    121         0    122      6694    123      6704    124         0

SAVEX NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
     130        55    131      6566    132      6618    133      6636    134      6673
     135        88    136      6695    137      6695    138        89    139       177
     140      6710    141         0    142      6710    143      6743    144         0

SAVEX NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
     100        56    101      6648    102      6683    103      6704    104      6787
     105       118    106      1111    107         0    108        21    109       139

SAVEX NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
     170        53    171      6684    172      6806    173         0    174         0
     175       122    176         0    177         0    178         0    179       122

SAVEX NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
     150        55    151      6651    152      6710    153      6798    154      6798
     155       118    156      6828    157         0    158        59    159       177

SAVEX NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
     110        56    111      6704    112      6704    113      6767    114      6767
     115       138    116      6842    117      6842    118         0    119       136
     120      6842    121      1111    122      6842    123      6842    124         0

SAVEX NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
     160        55    161      6684    162      6694    163      6798    164      6851
     165        73    166      6851    167      6861    168       104    169       177

SAVEX NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
     100        57    101      6787    102      6832    103      6842    104      6925
     105       128    106         0    107         0    108        10    109       138

SAVEX NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
     110        57    111      6842    112      6842    113      6905    114      6905
     115       135    116      6950    117      6950    118         4    119       139
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	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	120	6967	121	0	122	6971	123	6981	124	0
SAVEX	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE
	170	55	171	6861	172	6983	173	0	174	0
	175	122	176	0	177	0	178	0	179	122
SAVEX	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE
	130	57	131	6787	132	6787	133	6805	134	6950
	135	88	136	6972	137	6972	138	145	139	233
	140	6987	141	0	142	6987	143	7020	144	0
SAVEX	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE
	100	58	101	6925	102	6970	103	6981	104	7065
	105	129	106	0	107	0	108	11	109	140
SAVEX	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE
	150	57	151	6828	152	6987	153	7075	154	7075
	155	118	156	7105	157	0	158	159	159	277
SAVEX	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE
	110	58	111	6981	112	6981	113	7045	114	7045
	115	136	116	7090	117	7090	118	4	119	140
	120	7107	121	0	122	7111	123	7121	124	0
SAVEX	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE
	160	57	161	6861	162	6871	163	7075	164	7128
	165	73	166	7128	167	7138	168	204	169	277
SAVEX	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE
	130	58	131	7020	132	7035	133	7053	134	7090
	135	88	136	7112	137	7112	138	52	139	140
	140	7127	141	0	142	7127	143	7160	144	0
SAVEX	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE
	100	59	101	7065	102	7110	103	7121	104	7204
	105	128	106	0	107	0	108	11	109	139
SAVEX	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE
	150	58	151	7105	152	7127	153	7215	154	7215
	155	118	156	7245	157	0	158	22	159	140
SAVEX	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE
	170	57	171	7138	172	7260	173	0	174	0
	175	122	176	0	177	0	178	0	179	122
SAVEX	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE
	110	59	111	7121	112	7121	113	7184	114	7184
	115	135	116	7229	117	7229	118	4	119	139
	120	7246	121	0	122	7250	123	7260	124	0
SAVEX	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE
	160	58	161	7138	162	7148	163	7215	164	7268
	165	73	166	7268	167	7278	168	67	169	140
SAVEX	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE	NR.........	VALUE
	130	59	131	7160	132	7174	133	7194	134	7229
	135	92	136	7253	137	7253	138	49	139	141

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        140         7268   141         0   142         7268   143         7301   144         0

SAVEX   NR.........VALUE   NR.......VALUE   NR.......VALUE   NR.......VALUE   NR.........VALUE
        100           60   101      7204   102      7249   103      7360   104         7342
        105          127   106         0   107         0   108        11   109          136

SAVEX   NR.........VALUE   NR.......VALUE   NR.......VALUE   NR.......VALUE   NR.........VALUE
        150           59   151      7245   152      7268   153      7356   154         7356
        155          118   156      7386   157         0   158        23   159          141

SAVEX   NR.........VALUE   NR.......VALUE   NR.......VALUE   NR.......VALUE   NR.........VALUE
        110           60   111      7260   112      7260   113      7322   114         7322
        115          134   116      7367   117      7367   118         4   119          138
        120         7384   121         0   122      7388   123      7398   124            0

SAVEX   NR.........VALUE   NR.......VALUE   NR.......VALUE   NR.......VALUE   NR.........VALUE
        170           58   171      7278   172      7400   173         0   174            0
        175          122   176         0   177         0   178         0   179          122

SAVEX   NR.........VALUE   NR.......VALUE   NR.......VALUE   NR.......VALUE   NR.........VALUE
        160           59   161      7278   162      7288   163      7356   164         7409
        165           73   166      7409   167      7419   168        68   169          141

SAVEX   NR.........VALUE   NR.......VALUE   NR.......VALUE   NR.......VALUE   NR.........VALUE
        130           60   131      7301   132      7312   133      7330   134         7367
        135           88   136      7389   137      7389   138        48   139          136
        140         7404   141         0   142      7404   143      7437   144            0

SAVEX   NR.........VALUE   NR.......VALUE   NR.......VALUE   NR.......VALUE   NR.........VALUE
        100           61   101      7342   102      7387   103      7398   104         7481
        105          128   106         0   107         0   108        11   109          139

SAVEX   NR.........VALUE   NR.......VALUE   NR.......VALUE   NR.......VALUE   NR.........VALUE
        150           60   151      7386   152      7404   153      7492   154         7492
        155          118   156      7522   157         0   158        18   159          136

SAVEX   NR.........VALUE   NR.......VALUE   NR.......VALUE   NR.......VALUE   NR.........VALUE
        110           61   111      7398   112      7398   113      7461   114         7461
        115          135   116      7506   117      7506   118         4   119          139
        120         7523   121         0   122      7527   123      7527   124            0

SAVEX   NR.........VALUE   NR.......VALUE   NR.......VALUE   NR.......VALUE   NR.........VALUE
        170           59   171      7419   172      7541   173         0   174            0
        175          122   176         0   177         0   178         0   179          122

SAVEX   NR.........VALUE   NR.......VALUE   NR.......VALUE   NR.......VALUE   NR.........VALUE
        160           60   161      7419   162      7429   163      7492   164         7545
        165           73   166      7545   167      7555   168        63   169          136

SAVEX   NR.........VALUE   NR.......VALUE   NR.......VALUE   NR.......VALUE   NR.........VALUE
        130           61   131      7437   132      7451   133      7470   134         7506
        135           90   136      7529   137      7529   138        50   139          140
        140         7544   141         0   142      7544   143      7577   144            0

SAVEX   NR.........VALUE   NR.......VALUE   NR.......VALUE   NR.......VALUE   NR.........VALUE
        100           62   101      7481   102      7526   103      7537   104         7624
        105          132   106         0   107         0   108        11   109          143
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SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	150	61	151	7522	152	7544	153	7632	154	7632
	155	118	156	7662	157	0	158	22	159	140

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	170	60	171	7565	172	7677	173	0	174	0
	175	122	176	0	177	0	178	0	179	122

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	110	62	111	7537	112	7537	113	7604	114	7604
	115	139	116	7649	117	7649	118	4	119	143
	120	7666	121	0	122	7670	123	7680	124	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	160	61	161	7555	162	7565	163	7632	164	7685
	165	73	166	7685	167	7695	168	67	169	140

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	130	62	131	7577	132	7594	133	7612	134	7649
	135	88	136	7671	137	7671	138	54	139	142
	140	7686	141	0	142	7686	143	7719	144	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	100	63	101	7624	102	7669	103	7680	104	7767
	105	132	106	0	107	0	108	11	109	143

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	150	62	151	7662	152	7686	153	7774	154	7774
	155	118	156	7804	157	0	158	24	159	142

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	170	61	171	7695	172	7817	173	0	174	0
	175	122	176	0	177	0	178	0	179	122

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	110	63	111	7680	112	7680	113	7747	114	7747
	115	139	116	7792	117	7792	118	4	119	143
	120	7809	121	0	122	7813	123	7823	124	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	160	62	161	7695	162	7705	163	7774	164	7827
	165	73	166	7827	167	7837	168	69	169	142

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	130	63	131	7719	132	7737	133	7760	134	7792
	135	98	136	7819	137	7819	138	50	139	148
	140	7834	141	0	142	7834	143	7867	144	0

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	100	64	101	7767	102	7802	103	7823	104	7907
	105	119	106	1111	107	0	108	21	109	140

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	150	63	151	7804	152	7834	153	7922	154	7922
	155	118	156	7952	157	0	158	30	159	148

SAVEX	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE

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      170          62    171        7837    172        7959    173           0    174           0
      175         122    176           0    177           0    178           0    179         122

SAVEX NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
      110          64    111        7823    112        7823    113        7887    114        7887
      115         139    116        7962    117        7962    118           0    119         139
      120        7962    121        1111    122        7962    123        7962    124           0

SAVEX NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
      160          63    161        7837    162        7847    163        7922    164        7975
      165          73    166        7975    167        7985    168          75    169         148

SAVEX NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
      100          65    101        7907    102        7952    103        7962    104        8045
      105         128    106           0    107           0    108          10    109         138

SAVEX NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
      100          66    101        8045    102        8045    103        8045    104        8045
      105           0    106           1    107           0    108           0    109           0

SAVEX NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
      110          65    111        7962    112        7962    113        8025    114        8025
      115         135    116        8070    117        8070    118           4    119         139
      120        8087    121           0    122        8091    123        8101    124           0

SAVEX NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
      110          66    111        8101    112        8101    113        8101    114        8101
      115           0    116        8101    117        8101    118           0    119           0
      120        8101    121           0    122        8101    123        8101    124           0

SAVEX NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
      170          63    171        7985    172        8107    173           0    174           0
      175         122    176           0    177           0    178           0    179         122

SAVEX NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
      130          65    131        7907    132        7907    133        7925    134        8070
      135          88    136        8092    137        8092    138         145    139         233
      140        8107    141           0    142        8107    143        8140    144           0

SAVEX NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
      150          65    151        7952    152        8107    153        8195    154        8195
      155         118    156        8225    157           0    158         155    159         273

SAVEX NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
      100          67    101        8045    102        8090    103        8101    104        8229
      105         173    106           0    107           0    108          11    109         184

SAVEX NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
      160          65    161        7985    162        7995    163        8195    164        8248
      165          73    166        8248    167        8258    168         200    169         273

SAVEX NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
      110          67    111        8101    112        8101    113        8209    114        8209
      115         180    116        8254    117        8254    118           4    119         184
      120        8271    121           0    122        8275    123        8265    124           0

SAVEX NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
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	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	130	67	131	8140	132	8199	133	8218	134	8254
	135	90	136	8277	137	8277	138	95	139	185
	140	8292	141	0	142	8292	143	8325	144	0

SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	100	68	101	8229	102	8274	103	8285	104	8369
	105	129	106	0	107	0	108	11	109	140

SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	170	65	171	8258	172	8380	173	0	174	0
	175	122	176	0	177	0	178	0	179	122

SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	150	67	151	8225	152	8292	153	8360	154	8380
	155	118	156	8410	157	0	158	67	159	185

SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	110	68	111	8285	112	8285	113	8349	114	8349
	115	136	116	8394	117	8394	118	4	119	140
	120	8411	121	0	122	8415	123	8425	124	0

SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	160	67	161	8258	162	8268	163	8360	164	8433
	165	73	166	8433	167	8443	168	112	169	185

SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	130	68	131	8325	132	8339	133	8359	134	8394
	135	92	136	8418	137	8418	138	49	139	141
	140	8433	141	0	142	8433	143	8466	144	0

SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	100	69	101	8369	102	8414	103	8425	104	8502
	105	128	106	0	107	0	108	11	109	139

SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	150	68	151	8410	152	8433	153	8521	154	8521
	155	118	156	8551	157	0	158	23	159	141

SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	110	69	111	8425	112	8425	113	8488	114	8488
	115	135	116	8533	117	8533	118	4	119	139
	120	8550	121	0	122	8554	123	8564	124	0

SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	170	67	171	8443	172	8565	173	0	174	0
	175	122	176	0	177	0	178	0	179	122

SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	160	68	161	8443	162	8453	163	8521	164	8574
	165	73	166	8574	167	8584	168	68	169	141

SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	130	69	131	8466	132	8478	133	8496	134	8533
	135	88	136	8555	137	8555	138	49	139	137
	140	8570	141	0	142	8570	143	8603	144	0

SAVEX NR........VALUE NR........VALUE NR........VALUE NR........VALUE NR........VALUE

	100	70	101	8508	102	8553	103	8564	104	8647
	105	128	106	0	107	0	108	11	109	135
SAVEX	NR.........	VALUE	NR.........	VALLE	NR.........	VALLE	NR.........	VALLE	NR.........	VALLE
	100	71	101	8647	102	8647	103	8647	104	8647
	105	0	106	1	107	0	108	0	109	0
SAVEX	NR.........	VALUE	NR.........	VALLE	NR.........	VALLE	NR.........	VALLE	NR.........	VALLE
	150	69	151	8551	152	8570	153	8658	154	8658
	155	118	156	8688	157	0	158	19	159	137
SAVEX	NR.........	VALUE	NR.........	VALLE	NR.........	VALLE	NR.........	VALLE	NR.........	VALLE
	110	70	111	8564	112	8564	113	8627	114	8627
	115	135	116	8672	117	8672	118	4	119	139
	120	8689	121	0	122	8693	123	8703	124	0
SAVEX	NR.........	VALUE	NR.........	VALLE	NR.........	VALLE	NR.........	VALLE	NR.........	VALLE
	110	71	111	8703	112	8703	113	8703	114	8703
	115	0	116	8703	117	8703	118	0	119	0
	120	8703	121	0	122	8703	123	8703	124	0
SAVEX	NR.........	VALUE	NR.........	VALLE	NR.........	VALLF	NR.........	VALLE	NR.........	VALLE
	170	68	171	8584	172	8706	173	0	174	0
	175	122	176	0	177	0	178	0	179	122
SAVEX	NR.........	VALUE	NR.........	VALLE	NR.........	VALLE	NR.........	VALLE	NR.........	VALLE
	160	69	161	8584	162	8594	163	8658	164	8711
	165	73	166	8711	167	8721	168	64	169	137
SAVEX	NR.........	VALUE	NR.........	VALLE	NR.........	VALLE	NR.........	VALLE	NR.........	VALLE
	130	70	131	8603	132	8617	133	8636	134	8672
	135	90	136	8695	137	8695	138	50	139	140
	140	8710	141	0	142	8710	143	8743	144	0
SAVEX	NR.........	VALUE	NR.........	VALLE	NR.........	VALLF	NR.........	VALLE	NR.........	VALLE
	150	70	151	8628	152	8710	153	8758	154	8758
	155	118	156	8828	157	0	158	22	159	140
SAVEX	NR.........	VALLE	NR.........	VALLE	NR.........	VALLF	NR.........	VALLE	NR.........	VALLE
	100	72	101	8647	102	8692	103	8763	104	8831
	105	173	106	0	107	0	108	11	109	184
SAVEX	NR.........	VALUE	NR.........	VALLE	NR.........	VALLF	NR.........	VALLE	NR.........	VALLE
	170	69	171	8721	172	8893	173	0	174	0
	175	122	176	0	177	0	178	0	179	122
SAVEX	NR.........	VALLE	NR.........	VALLE	NR.........	VALLF	NR.........	VALLE	NR.........	VALLE
	160	70	161	8721	162	8731	163	8798	164	8851
	165	73	166	8851	167	8861	168	67	169	140
SAVEX	NR.........	VALLE	NR.........	VALLE	NR.........	VALLF	NR.........	VALLE	NR.........	VALLE
	110	72	111	8703	112	8703	113	8811	114	8811
	115	180	116	8856	117	8856	118	4	119	164
	120	8873	121	0	122	8877	123	8887	124	0
SAVEX	NR.........	VALLF	NR.........	VALLE	NR.........	VALLF	NR.........	VALLE	NR.........	VALLE
	130	72	131	8743	132	8801	133	8819	134	8856

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      135        88   136      8878   137      8878   138        95   139       183
      140      8893   141         0   142      8893   143      8926   144         0

SAVEX NR........VALLE NR........VALLE NR........VALLE NR........VALLE NR........VALLE
      100        73   101      8831   102      8876   103      8887   104      8972
      105       130   106         0   107         0   108        11   109       141

SAVEX NR........VALLE NR........VALLE NR........VALLE NR........VALLE NR........VALLE
      170        70   171      8861   172      8983   173         0   174         0
      175       122   176         0   177         0   178         0   179       122

SAVEX NR........VALLE NR........VALLE NR........VALLE NR........VALLE NR........VALLE
      150        72   151      8828   152      8893   153      8981   154      8981
      155       118   156      9011   157         0   158        65   159       183

SAVEX NR........VALLE NR........VALLE NR........VALLE NR........VALLE NR........VALLE
      110        73   111      8887   112      8887   113      8952   114      8952
      115       137   116      8997   117      8997   118         4   119       141
      120      9014   121         0   122      9018   123      9028   124         0

SAVEX NR........VALLE NR........VALLE NR........VALLE NR........VALLE NR........VALLE
      160        72   161      8861   162      8871   163      8981   164      9034
      165        73   166      9034   167      9044   168       110   169       183

SAVEX NR........VALLE NR........VALLE NR........VALLE NR........VALLE NR........VALLE
      130        73   131      8926   132      8942   133      8963   134      8997
      135        94   136      9022   137      9022   138        50   139       144
      140      9037   141         0   142      9037   143      9070   144         0

SAVEX NR........VALLE NR........VALLE NR........VALLE NR........VALLE NR........VALLE
      100        74   101      8972   102      9017   103      9028   104      9110
      105       127   106         0   107         0   108        11   109       138

SAVEX NR........VALLE NR........VALLE NR........VALLE NR........VALLE NR........VALLE
      150        73   151      9011   152      9037   153      9125   154      9123
      155       118   156      9155   157         0   158        26   159       144

SAVEX NR........VALLE NR........VALLE NR........VALLE NR........VALLE NR........VALLE
      170        72   171      9044   172      9166   173         0   174         0
      175       122   176         0   177         0   178         0   179       122

SAVEX NR........VALLE NR........VALLE NR........VALLE NR........VALLE NR........VALLE
      110        74   111      9028   112      9028   113      9090   114      9090
      115       134   116      9135   117      9135   118         4   119       138
      120      9152   121         0   122      9156   123      9166   124         0

SAVEX NR........VALLE NR........VALLE NR........VALLE NR........VALLE NR........VALLE
      160        73   161      9044   162      9054   163      9125   164      9178
      165        73   166      9178   167      9188   168        71   169       144

SAVEX NR........VALLE NR........VALLE NR........VALLE NR........VALLE NR........VALLE
      130        74   131      9070   132      9080   133      9098   134      9135
      135        88   136      9157   137      9157   138        47   139       135
      140      9172   141         0   142      9172   143      9265   144         0

SAVEX NR........VALLE NR........VALLE NR........VALLE NR........VALLE NR........VALLE
      100        75   101      9110   102      9155   103      9166   104      9250
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	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
	105	129	106	0	107	0	108	11	109	140
SAVEX	NR.........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	150	74	151	9155	152	9172	153	9260	154	9260
	155	118	156	9290	157	0	158	17	159	135
SAVEX	NR.........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	110	75	111	9166	112	9166	113	9230	114	9230
	115	136	116	9275	117	9275	118	4	119	140
	120	9292	121	0	122	9296	123	9306	124	0
SAVEX	NR.........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	170	73	171	9188	172	9310	173	0	174	0
	175	122	176	0	177	0	178	0	179	122
SAVEX	NR.........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	160	74	161	9188	162	9198	163	9260	164	9313
	165	73	166	9313	167	9323	168	62	169	135
SAVEX	NR.........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	130	75	131	9205	132	9220	133	9239	134	9275
	135	90	136	9298	137	9298	138	51	139	141
	140	9313	141	0	142	9313	143	9346	144	0
SAVEX	NR.........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	100	76	101	9250	102	9295	103	9306	104	9391
	105	130	106	0	107	0	108	11	109	141
SAVEX	NR.........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	100	77	101	9391	102	9391	103	9391	104	9391
	105	0	106	1	107	0	108	0	109	0
SAVEX	NR.........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	150	75	151	9290	152	9313	153	9401	154	9401
	155	118	156	9431	157	0	158	23	159	141
SAVEX	NR.........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	170	74	171	9323	172	9445	173	0	174	0
	175	122	176	0	177	0	178	0	179	122
SAVEX	NR.........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	110	76	111	9306	112	9306	113	9371	114	9371
	115	137	116	9416	117	9416	118	4	119	141
	120	9433	121	0	122	9437	123	9447	124	0
SAVEX	NR.........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	110	77	111	9447	112	9447	113	9447	114	9447
	115	0	116	9447	117	9447	118	0	119	0
	120	9447	121	0	122	9447	123	9447	124	0
SAVEX	NR.........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	160	75	161	9323	162	9333	163	9401	164	9454
	165	73	166	9454	167	9464	168	68	169	141
SAVEX	NR.........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	130	76	131	9346	132	9361	133	9379	134	9416
	135	88	136	9438	137	9438	138	52	139	140

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       140          9453    141             0    142          9453    143          9486    144             0

SAVEX  NR........VALUE      NR........VALUE      NR........VALUE      NR........VALUE      NR........VALUE
       150            76    151          9431    152          9453    153          9541    154          9541
       155           118    156          9571    157             0    158            22    159           140

SAVEX  NR........VALUE      NR........VALUE      NR........VALUE      NR........VALUE      NR........VALUE
       100            78    101          9391    102          9436    103          9447    104          9575
       105           173    106             0    107             0    108            11    109           184

SAVEX  NR........VALUE      NR........VALUE      NR........VALUE      NR........VALUE      NR........VALUE
       170            75    171          9464    172          9586    173             0    174             0
       175           122    176             0    177             0    178             0    179           122

SAVEX  NR........VALUE      NR........VALUE      NR........VALUE      NR........VALUE      NR........VALUE
       160            76    161          9464    162          9474    163          9541    164          9554
       165            73    166          9594    167          9604    168            67    169           140

SAVEX  NR........VALUE      NR........VALUE      NR........VALUE      NR........VALUE      NR........VALUE
       110            78    111          9447    112          9447    113          9555    114          9555
       115           180    116          9600    117          9600    118             4    119           184
       120          9617    121             0    122          9621    123          9631    124             0

SAVEX  NR........VALUE      NR........VALUE      NR........VALUE      NR........VALUE      NR........VALUE
       130            78    131          9486    132          9545    133          9566    134          9600
       135            94    136          9625    137          9625    138            93    139           187
       140          9640    141             0    142          9640    143          9673    144             0

SAVEX  NR........VALUE      NR........VALUE      NR........VALUE      NR........VALUE      NR........VALUE
       100            79    101          9575    102          9620    103          9631    104          9717
       105           131    106             0    107             0    108            11    109           142

SAVEX  NR........VALUE      NR........VALUE      NR........VALUE      NR........VALUE      NR........VALUE
       170            76    171          9604    172          9726    173             0    174             0
       175           122    176             0    177             0    178             0    179           122

SAVEX  NR........VALUE      NR........VALUE      NR........VALUE      NR........VALUE      NR........VALUE
       150            78    151          9571    152          9640    153          9728    154          9728
       155           118    156          9758    157             0    158            69    159           187

SAVEX  NR........VALUE      NR........VALUE      NR........VALUE      NR........VALUE      NR........VALUE
       110            79    111          9631    112          9631    113          9697    114          9697
       115           138    116          9742    117          9742    118             4    119           142
       120          9759    121             0    122          9763    123          9773    124             0

SAVEX  NR........VALUE      NR........VALUE      NR........VALUE      NR........VALUE      NR........VALUE
       160            78    161          9604    162          9614    163          9728    164          9781
       165            73    166          9781    167          9791    168           114    169           187

SAVEX  NR........VALUE      NR........VALUE      NR........VALUE      NR........VALUE      NR........VALUE
       130            79    131          9673    132          9687    133          9705    134          9742
       135            88    136          9764    137          9764    138            51    139           139
       140          9779    141             0    142          9779    143          9812    144             0

SAVEX  NR........VALUE      NR........VALUE      NR........VALUE      NR........VALUE      NR........VALUE
       100            80    101          9717    102          9762    103          9773    104          9861
       105           133    106             0    107             0    108            11    109           144
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SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	150	79	151	9758	152	9779	153	9867	154	9867
	155	118	156	9897	157	0	158	21	159	139
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	170	78	171	9791	172	9913	173	0	174	0
	175	122	176	0	177	0	178	0	179	122
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	110	80	111	9773	112	9773	113	9841	114	9841
	115	140	116	9886	117	9886	118	4	119	144
	120	9903	121	0	122	9907	123	9917	124	0
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	160	79	161	9791	162	9801	163	9867	164	9920
	165	73	166	9920	167	9930	168	66	169	139
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	130	80	131	9812	132	9831	133	9853	134	9886
	135	96	136	9912	137	9912	138	52	139	148
	140	9927	141	0	142	9927	143	9960	144	0
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	100	81	101	9861	102	9906	103	9917	104	9999
	105	127	106	0	107	0	108	11	109	138
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	150	80	151	9897	152	9927	153	10015	154	10015
	155	118	156	10045	157	0	158	30	159	148
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	170	79	171	9930	172	10052	173	0	174	0
	175	122	176	0	177	0	178	0	179	122
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	110	81	111	9917	112	9917	113	9979	114	9979
	115	134	116	10024	117	10024	118	4	119	132
	120	10041	121	0	122	10045	123	10055	124	0
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	160	80	161	9930	162	9940	163	10015	164	10068
	165	73	166	10068	167	10078	168	75	169	148
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	130	81	131	9960	132	9969	133	9987	134	10024
	135	88	136	10046	137	10046	138	46	139	134
	140	10061	141	0	142	10061	143	10094	144	0
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	100	82	101	9999	102	10044	103	10055	104	10139
	105	129	106	0	107	0	108	11	109	140
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	150	81	151	10045	152	10061	153	10149	154	10149
	155	118	156	10179	157	0	158	16	159	134
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE

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        110         82   111      10055   112      10055   113      10119   114      10119
        115        136   116      10164   117      10164   118          4   119        140
        120      10181   121          0   122      10185   123      10195   124          0

SAVEX   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
        170         80   171      10078   172      10200   173          0   174          0
        175        122   176          0   177          0   178          0   179        122

SAVEX   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
        160         81   161      10078   162      10088   163      10149   164      10202
        165         73   166      10202   167      10212   168         61   169        134

SAVEX   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
        130         82   131      10094   132      10109   133      10127   134      10164
        135         88   136      10186   137      10186   138         52   139        140
        140      10201   141          0   142      10201   143      10234   144          0

SAVEX   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
        100         83   101      10139   102      10184   103      10195   104      10279
        105        129   106          0   107          0   108         11   109        140

SAVEX   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
        150         82   151      10179   152      10201   153      10289   154      10289
        155        118   156      10319   157          0   158         22   159        140

SAVEX   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
        170         81   171      10212   172      10334   173          0   174          0
        175        122   176          0   177          0   178          0   179        122

SAVEX   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
        110         83   111      10195   112      10195   113      10259   114      10259
        115        136   116      10304   117      10304   118          4   119        140
        120      10321   121          0   122      10325   123      10335   124          0

SAVEX   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
        160         82   161      10212   162      10222   163      10289   164      10342
        165         73   166      10342   167      10352   168         67   169        140

SAVEX   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
        130         83   131      10234   132      10249   133      10269   134      10304
        135         92   136      10328   137      10328   138         50   139        142
        140      10343   141          0   142      10343   143      10376   144          0

SAVEX   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
        100         84   101      10279   102      10324   103      10335   104      10418
        105        128   106          0   107          0   108         11   109        139

SAVEX   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
        100         85   101      10418   102      10418   103      10418   104      10418
        105          0   106          1   107          0   108          0   109          0

SAVEX   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
        150         83   151      10319   152      10343   153      10431   154      10431
        155        118   156      10461   157          0   158         24   159        142

SAVEX   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
        170         82   171      10352   172      10474   173          0   174          0
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        175          122     176          0     177          0     178          0     179          122

SAVEX   NR........VALUE     NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
        110           84     111      10335     112      10335     113      10398     114      10398
        115          135     116      10443     117      10443     118          4     119        139
        120        10460     121          0     122      10464     123      10474     124          0

SAVEX   NR........VALUE     NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
        110           85     111      10474     112      10474     113      10474     114      10474
        115            0     116      10474     117      10474     118          0     119          0
        120        10474     121          0     122      10474     123      10474     124          0

SAVEX   NR........VALUE     NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
        160           83     161      10352     162      10362     163      10431     164      10484
        165           73     166      10484     167      10494     168         69     169        142

SAVEX   NR........VALUE     NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
        130           84     131      10376     132      10388     133      10406     134      10443
        135           88     136      10465     137      10465     138         49     139        137
        140        10480     141          0     142      10480     143      10513     144          0

SAVEX   NR........VALUE     NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
        150           84     151      10461     152      10480     153      10568     154      10568
        155          118     156      10598     157          0     158         19     159        137

SAVEX   NR........VALUE     NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
        100           86     101      10418     102      10463     103      10474     104      10599
        105          170     106          0     107          0     108         11     109        181

SAVEX   NR........VALUE     NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
        100           87     101      10599     102      10599     103      10599     104      10599
        105            0     106          1     107          0     108          0     109          0

SAVEX   NR........VALUE     NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
        100           88     101      10599     102      10599     103      10599     104      10599
        105            0     106          1     107          0     108          0     109          0

SAVEX   NR........VALUE     NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
        170           83     171      10494     172      10616     173          0     174          0
        175          122     176          0     177          0     178          0     179        122

SAVEX   NR........VALUE     NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
        160           84     161      10494     162      10504     163      10568     164      10621
        165           73     166      10621     167      10631     168         64     169        137

SAVEX   NR........VALUE     NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
        110           86     111      10474     112      10474     113      10579     114      10579
        115          177     116      10624     117      10624     118          4     119        181
        120        10641     121          0     122      10645     123      10655     124          0

SAVEX   NR........VALUE     NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
        110           87     111      10655     112      10655     113      10655     114      10655
        115            0     116      10655     117      10655     118          0     119          0
        120        10655     121          0     122      10655     123      10655     124          0

SAVEX   NR........VALUE     NR........VALUE    NR........VALUE    NR........VALUE    NR........VALUE
        110           88     111      10655     112      10655     113      10655     114      10655
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	115	0	116	10655	117	10655	118	0	119	0
	120	10655	121	0	122	10655	123	10655	124	0

SAVEX	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE
	130	86	131	10513	132	10569	133	10567	134	10624
	135	88	136	10646	137	10646	138	93	139	181
	140	10661	141	0	142	10661	143	10694	144	0

SAVEX	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE
	170	84	171	10631	172	10753	173	0	174	0
	175	122	176	0	177	0	178	0	179	122

SAVEX	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE
	150	86	151	10598	152	10661	153	10749	154	10749
	155	118	156	10779	157	0	158	63	159	181

SAVEX	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE
	160	86	161	10631	162	10641	163	10749	164	10802
	165	73	166	10802	167	10812	168	108	169	181

SAVEX	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE
	100	89	101	10599	102	10634	103	10655	104	10823
	105	203	106	1111	107	0	108	21	109	224

SAVEX	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE
	110	89	111	10655	112	10655	113	10803	114	10803
	115	223	116	10878	117	10878	118	0	119	223
	120	10878	121	1111	122	10878	123	10878	124	0

SAVEX	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE
	170	86	171	10812	172	10934	173	0	174	0
	175	122	176	0	177	0	178	0	179	122

SAVEX	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE
	100	90	101	10823	102	10868	103	10878	104	10962
	105	129	106	0	107	0	108	10	109	139

SAVEX	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE
	110	90	111	10878	112	10878	113	10942	114	10942
	115	136	116	10987	117	10987	118	4	119	140
	120	11004	121	0	122	11008	123	11018	124	0

SAVEX	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE
	130	90	131	10823	132	10823	133	10841	134	10987
	135	88	136	11009	137	11009	138	146	139	234
	140	11024	141	0	142	11024	143	11057	144	0

SAVEX	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE
	100	91	101	10962	102	11007	103	11018	104	11102
	105	129	106	0	107	0	108	11	109	140

SAVEX	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE
	150	90	151	10823	152	11024	153	11112	154	11112
	155	118	156	11142	157	0	158	201	159	319

SAVEX	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE
	110	91	111	11018	112	11018	113	11082	114	11082

	115	136	116	11127	117	11127	118	4	119	140
	120	11144	121	0	122	11148	123	11158	124	0
SAVEX	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE
	160	90	161	10823	162	10833	163	11112	164	11165
	165	73	166	11165	167	11175	168	279	169	352
SAVEX	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE
	130	91	131	11057	132	11072	133	11091	134	11127
	135	90	136	11150	137	11150	138	51	139	141
	140	11165	141	0	142	11165	143	11196	144	0
SAVEX	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE
	100	92	101	11102	102	11147	103	11158	104	11243
	105	130	106	0	107	0	108	11	109	141
SAVEX	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE
	100	93	101	11243	102	11243	103	11243	104	11243
	105	0	106	1	107	0	108	0	109	0
SAVEX	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE
	100	94	101	11243	102	11243	103	11243	104	11243
	105	0	106	1	107	0	108	0	109	0
SAVEX	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE
	150	91	151	11142	152	11165	153	11253	154	11253
	155	118	156	11283	157	0	158	23	159	141
SAVEX	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE
	170	90	171	11175	172	11297	173	0	174	0
	175	122	176	0	177	0	178	0	179	122
SAVEX	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE
	110	92	111	11158	112	11158	113	11223	114	11223
	115	137	116	11268	117	11268	118	4	119	141
	120	11285	121	0	122	11289	123	11299	124	0
SAVEX	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE
	110	93	111	11299	112	11299	113	11299	114	11299
	115	0	116	11299	117	11299	118	0	119	0
	120	11299	121	0	122	11299	123	11299	124	0
SAVEX	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE
	110	94	111	11299	112	11299	113	11299	114	11299
	115	0	116	11299	117	11299	118	0	119	0
	120	11299	121	0	122	11299	123	11299	124	0
SAVEX	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE
	160	91	161	11175	162	11185	163	11253	164	11306
	165	73	166	11306	167	11316	168	68	169	141
SAVEX	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE
	130	92	131	11198	132	11213	133	11232	134	11268
	135	90	136	11291	137	11291	138	51	139	141
	140	11306	141	0	142	11306	143	11339	144	0
SAVEX	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE	NR	........VALUE

	150	92	151	11283	152	11308	153	11394	154	11394
	155	118	156	11424	157	0	158	23	159	141
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	170	91	171	11316	172	11438	173	0	174	0
	175	122	176	0	177	0	178	0	179	122
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	160	92	161	11316	162	11326	163	11394	164	11447
	165	73	166	11447	167	11457	168	68	169	141
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	100	95	101	11243	102	11288	103	11299	104	11470
	105	216	106	0	107	0	108	11	109	227
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	110	95	111	11299	112	11299	113	11450	114	11450
	115	223	116	11455	117	11495	118	4	119	227
	120	11512	121	0	122	11516	123	11526	124	0
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	130	95	131	11339	132	11440	133	11461	134	11495
	135	94	136	11520	137	11520	138	135	139	229
	140	11535	141	0	142	11535	143	11568	144	0
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	170	92	171	11457	172	11579	173	0	174	0
	175	122	176	0	177	0	178	0	179	122
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	100	96	101	11470	102	11515	103	11526	104	11612
	105	131	106	0	107	0	108	11	109	142
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	100	97	101	11612	102	11612	103	11612	104	11612
	105	0	106	1	107	0	108	0	109	0
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	150	95	151	11424	152	11535	153	11623	154	11623
	155	118	156	11653	157	0	158	111	159	229
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	110	96	111	11526	112	11526	113	11592	114	11592
	115	138	116	11637	117	11637	118	4	119	142
	120	11654	121	0	122	11658	123	11668	124	0
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	110	97	111	11668	112	11668	113	11668	114	11668
	115	0	116	11668	117	11668	118	0	119	0
	120	11668	121	0	122	11668	123	11668	124	0
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	160	95	161	11457	162	11467	163	11623	164	11676
	165	73	166	11676	167	11686	168	156	169	229
SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	130	96	131	11568	132	11582	133	11600	134	11637

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        135           88    136       11659    137       11659    138          51    139         139
        140        11674    141           0    142       11674    143       11707    144           0

SAVEX   NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE
        150           96    151       11653    152       11674    153       11762    154       11762
        155          118    156       11792    157           0    158          21    159         139

SAVEX   NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE
        100           98    101       11612    102       11657    103       11668    104       11793
        105          170    106           0    107           0    108          11    109         181

SAVEX   NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE
        170           95    171       11686    172       11808    173           0    174           0
        175          122    176           0    177           0    178           0    179         122

SAVEX   NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE
        160           96    161       11686    162       11696    163       11762    164       11815
        165           73    166       11615    167       11825    168          66    169         135

SAVEX   NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE
        110           98    111       11668    112       11668    113       11773    114       11773
        115          177    116       11818    117       11818    118           4    119         181
        120        11835    121           0    122       11839    123       11649    124           0

SAVEX   NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE
        130           98    131       11707    132       11763    133       11785    134       11818
        135           96    136       11844    137       11844    138          89    139         185
        140        11859    141           0    142       11859    143       11692    144           0

SAVEX   NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE
        100           99    101       11793    102       11838    103       11849    104       11932
        105          128    106           0    107           0    108          11    109         139

SAVEX   NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE
        170           96    171       11825    172       11947    173           0    174           0
        175          122    176           0    177           0    178           0    179         122

SAVEX   NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE
        150           98    151       11792    152       11859    153       11947    154       11947
        155          118    156       11977    157           0    158          67    159         185

SAVEX   NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE
        110           99    111       11849    112       11849    113       11912    114       11912
        115          135    116       11957    117       11957    118           4    119         135
        120        11974    121           0    122       11978    123       11988    124           0

SAVEX   NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE
        160           98    161       11825    162       11835    163       11947    164       12000
        165           73    166       12000    167       12010    168         112    169         185

SAVEX   NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE
        130           99    131       11892    132       11902    133       11924    134       11957
        135           96    136       11983    137       11983    138          43    139         139
        140        11998    141           0    142       11998    143       12031    144           0

SAVEX   NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE     NR........VALUE
        100          100    101       11932    102       11977    103       11988    104       12074
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      105          131    106            0    107            0    108           11    109          142

SAVEX NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE
      150           99    151        11977    152        11998    153        12066    154        12086
      155          118    156        12116    157            0    158           21    159          139

SAVEX NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE
      110          100    111        11988    112        11988    113        12054    114        12054
      115          138    116        12099    117        12099    118            4    119          142
      120        12116    121            0    122        12120    123        12130    124            0

SAVEX NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE
      170           98    171        12010    172        12132    173            0    174            0
      175          122    176            0    177            0    178            0    179          122

SAVEX NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE
      160           99    161        12010    162        12020    163        12066    164        12139
      165           73    166        12139    167        12149    168           66    169          139

SAVEX NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE
      130          100    131        12031    132        12044    133        12065    134        12099
      135           94    136        12124    137        12124    138           47    139          141
      140        12139    141            0    142        12139    143        12172    144            0

SAVEX NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE
      100          101    101        12074    102        12119    103        12130    104        12212
      105          127    106            0    107            0    108           11    109          138

SAVEX NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE
      150          100    151        12116    152        12139    153        12227    154        12227
      155          118    156        12257    157            0    158           23    159          141

SAVEX NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE
      110          101    111        12130    112        12130    113        12192    114        12192
      115          134    116        12237    117        12237    118            4    119          138
      120        12254    121            0    122        12258    123        12268    124            0

SAVEX NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE
      170           99    171        12149    172        12271    173            0    174            0
      175          122    176            0    177            0    178            0    179          122

SAVEX NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE
      160          100    161        12149    162        12159    163        12227    164        12280
      165           73    166        12280    167        12290    168           68    169          141

SAVEX NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE
      130          101    131        12172    132        12182    133        12200    134        12237
      135           88    136        12259    137        12259    138           47    139          135
      140        12274    141            0    142        12274    143        12307    144            0

SAVEX NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE
      100          102    101        12212    102        12257    103        12268    104        12353
      105          130    106            0    107            0    108           11    109          141

SAVEX NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE    NR.........VALUE
      150          101    151        12257    152        12274    153        12362    154        12362
      155          118    156        12392    157            0    158           17    159          139
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SAVEX  NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
        110         102   111       12268   112       12268   113       12333   114       12333
        115         137   116       12378   117       12378   118           4   119         141
        120       12395   121           0   122       12395   123       12469   124           0

SAVEX  NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
        170         100   171       12290   172       12412   173           0   174           0
        175         122   176           0   177           0   178           0   179         122

SAVEX  NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
        160         101   161       12290   162       12300   163       12362   164       12415
        165          73   166       12415   167       12425   168          62   169         135

SAVEX  NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
        130         102   131       12307   132       12323   133       12341   134       12378
        135          88   136       12400   137       12400   138          53   139         141
        140       12415   141           0   142       12415   143       12448   144           0

SAVEX  NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
        100         103   101       12353   102       12398   103       12469   104       12493
        105         129   106           0   107           0   108          11   109         140

SAVEX  NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
        150         102   151       12392   152       12415   153       12503   154       12503
        155         118   156       12533   157           0   158          23   159         141

SAVEX  NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
        170         101   171       12425   172       12547   173           0   174           0
        175         122   176           0   177           0   178           0   179         122

SAVEX  NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
        110         103   111       12409   112       12409   113       12473   114       12473
        115         136   116       12518   117       12518   118           4   119         140
        120       12535   121           0   122       12539   123       12549   124           0

SAVEX  NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
        160         102   161       12425   162       12435   163       12503   164       12556
        165          73   166       12556   167       12566   168          68   169         141

SAVEX  NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
        130         103   131       12448   132       12463   133       12483   134       12518
        135          92   136       12542   137       12542   138          50   139         142
        140       12557   141           0   142       12557   143       12590   144           0

SAVEX  NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
        100         104   101       12493   102       12538   103       12549   104       12635
        105         131   106           0   107           0   108          11   109         142

SAVEX  NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
        150         103   151       12533   152       12557   153       12645   154       12645
        155         118   156       12675   157           0   158          24   159         142

SAVEX  NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
        170         102   171       12566   172       12688   173           0   174           0
        175         122   176           0   177           0   178           0   179         122

SAVEX  NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE   NR........VALUE
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	110	104	111	12549	112	12549	113	12615	114	12615
	115	138	116	12660	117	12660	118	4	119	142
	120	12677	121	0	122	12681	123	12691	124	0
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	160	103	161	12566	162	12576	163	12645	164	12698
	165	73	166	12698	167	12708	168	69	169	142
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	130	104	131	12590	132	12605	133	12623	134	12660
	135	88	136	12682	137	12682	138	52	139	140
	140	12697	141	0	142	12697	143	12730	144	0
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	100	105	101	12635	102	12680	103	12691	104	12774
	105	128	106	0	107	0	108	11	109	139
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	150	104	151	12675	152	12697	153	12765	154	12785
	155	118	156	12815	157	0	158	22	159	140
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	170	103	171	12708	172	12830	173	0	174	0
	175	122	176	0	177	0	178	0	179	122
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	110	105	111	12691	112	12691	113	12754	114	12754
	115	135	116	12799	117	12799	118	4	119	139
	120	12816	121	0	122	12820	123	12830	124	0
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	160	104	161	12708	162	12718	163	12785	164	12838
	165	73	166	12838	167	12848	168	67	169	140
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	130	105	131	12730	132	12744	133	12766	134	12799
	135	96	136	12825	137	12825	138	47	139	143
	140	12840	141	0	142	12840	143	12873	144	0
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	100	106	101	12774	102	12819	103	12830	104	12915
	105	130	106	0	107	0	108	11	109	141
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	150	105	151	12815	152	12840	153	12928	154	12928
	155	118	156	12958	157	0	158	25	159	143
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	170	104	171	12848	172	12970	173	0	174	0
	175	122	176	0	177	0	178	0	179	122
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	110	106	111	12830	112	12830	113	12895	114	12895
	115	137	116	12940	117	12940	118	4	119	141
	120	12957	121	0	122	12961	123	12971	124	0
SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	

	160	105	161	12848	162	12858	163	12926	164	12961
	165	73	166	12981	167	12991	168	70	169	143

SAVEX	NR.........VALUE		NR.........VALUE		NR.........VALUE		NR.........VALUE		NR.........VALUE	
	130	106	131	12873	132	12885	133	12906	134	12940
	135	94	136	12965	137	12965	138	46	139	140
	140	12980	141	0	142	12980	143	13013	144	0

SAVEX	NR.........VALUE		NR.........VALUE		NR.........VALUE		NR.........VALUE		NR.........VALUE	
	150	106	151	12958	152	12980	153	13068	154	13065
	155	118	156	13098	157	0	158	22	159	140

SAVEX	NR.........VALUE		NR.........VALUE		NR.........VALUE		NR.........VALUE		NR.........VALUE	
	170	105	171	12991	172	13113	173	0	174	0
	175	122	176	0	177	0	178	0	179	122

SAVEX	NR.........VALUE		NR.........VALUE		NR.........VALUE		NR.........VALUE		NR.........VALUE	
	160	106	161	12991	162	13001	163	13068	164	13121
	165	73	166	13121	167	13131	168	67	169	140

SAVEX	NR.........VALUE		NR.........VALUE		NR.........VALUE		NR.........VALUE		NR.........VALUE	
	170	106	171	13131	172	13253	173	0	174	0
	175	122	176	0	177	0	178	0	179	122

CLOCK TIME REL 14574 ABS 14574

TRANS COUNTS	BLOCK	TRANS,	TOTAL	BLOCK	TRANS,	TOTAL	BLOCK	TRANS,	TOTAL	BLOCK	TRANS,	TOTAL	BLOCK	TRANS,	TOTAL
	1	0,	106	2	0,	106	3	0,	106	4	0,	106	5	0,	106
	6	0,	106	7	0,	106	8	0,	106	9	0,	106	10	0,	106
	11	0,	106	12	0,	0	13	0,	0	14	0,	0	15	0,	0
	16	0,	0	17	0,	0	18	0,	0	19	0,	0	20	0,	106
	21	0,	86	22	0,	81	23	0,	86	24	0,	86	25	0,	86
	26	0,	86	27	0,	106	28	0,	106	29	0,	106	30	0,	106
	31	0,	20	32	0,	20	33	0,	20	34	0,	20	35	0,	106
	36	0,	86	37	0,	86	38	0,	5	39	0,	81	40	0,	86
	41	0,	86	42	0,	81	43	0,	81	44	0,	81	45	0,	81
	46	0,	106	47	0,	106	48	0,	106	49	0,	106	50	0,	106
	51	0,	1	52	0,	1	53	0,	1	54	0,	1	55	0,	1
	56	0,	1	57	0,	1	58	0,	1	59	0,	0	60	0,	1
	61	0,	1	62	0,	0	63	0,	0	64	0,	0	65	0,	0
	66	0,	0	67	0,	0	68	0,	0	69	0,	0	70	0,	106
	71	0,	106	72	0,	1	73	0,	0	74	0,	106	75	0,	106
	76	0,	106	77	0,	81	78	0,	81	79	0,	81	80	0,	106
	81	0,	0	82	0,	0	83	0,	0	84	0,	0	85	0,	106
	86	0,	86	87	0,	86	88	0,	86	89	0,	81	90	0,	0
	91	0,	5	92	0,	0	93	0,	0	94	0,	0	95	0,	86
	96	0,	86	97	0,	86	98	0,	86	99	0,	86	100	0,	86
	101	0,	86	102	0,	86	103	0,	86	104	0,	86	105	0,	86
	106	0,	86	107	0,	86	108	0,	106	109	0,	106	110	0,	106
	111	0,	20	112	0,	20	113	0,	20	114	0,	20	115	0,	20
	116	0,	20	117	0,	20	118	0,	20	119	0,	20	120	0,	0
	126	0,	0	127	0,	0	128	0,	106	129	0,	106	130	0,	106
	131	0,	106	132	0,	106	133	0,	106	134	0,	106	135	0,	106
	136	0,	106	137	0,	106	138	0,	106	139	0,	106	140	0,	0
	146	0,	86	147	0,	86	148	0,	86	149	0,	86	150	0,	81
	151	0,	86	152	0,	86	153	0,	86	154	0,	86	155	0,	86
	156	0,	86	157	0,	86	158	0,	86	159	0,	86	160	0,	86

161	0.	86	162	0.	86	163	0.	86	164	0.	86	165	0.	86
166	0.	[illegible]	167	0.	86	168	0.	86	169	0.	86	170	0.	86
171	0.	86	172	0.	86	173	0.	86	174	0.	5	175	0.	5
176	0.	5	177	0.	0	178	0.	0	179	0.	0	180	0.	0
196	0.	86	197	0.	[illegible]	198	0.	86	199	0.	81	200	0.	81
201	0.	81	202	0.	81	203	0.	81	204	0.	81	205	0.	81
206	0.	81	207	0.	106	208	0.	106	209	0.	106	210	0.	106
211	0.	106	212	0.	0	213	0.	0	214	0.	0	215	0.	0
221	0.	0	222	0.	0	223	0.	0	224	0.	81	225	0.	81
226	0.	81	227	0.	81	228	0.	81	229	0.	81	230	0.	81
231	0.	81	232	0.	81	233	0.	81	234	0.	81	235	0.	81
236	0.	0	237	0.	0	238	0.	81	239	0.	81	240	0.	81
241	0.	81	242	0.	81	243	0.	81	244	0.	81	245	0.	162
246	0.	81	247	0.	81	248	0.	81	249	0.	81	250	0.	81
251	0.	81	252	0.	81	253	0.	81	254	0.	81	255	0.	81
256	0.	243	257	0.	81	258	0.	81	259	0.	0	260	0.	81
261	0.	81	262	0.	81	263	0.	81	264	0.	162	265	0.	81
266	0.	81	267	0.	81	268	0.	81	269	0.	81	270	0.	81
271	0.	81	272	0.	81	273	0.	81	274	0.	81	275	0.	81
276	0.	81	277	0.	243	278	0.	81	279	0.	81	280	0.	81
281	0.	81	282	0.	81	283	0.	81	284	0.	0	285	0.	0
296	0.	0	297	0.	0	298	0.	0	299	0.	0	300	0.	81
301	0.	81	302	0.	81	303	0.	81	304	0.	81	305	0.	81
306	0.	81	307	0.	81	308	0.	81	309	0.	81	310	0.	81
311	0.	81	312	0.	81	313	0.	0	314	0.	81	315	0.	81
316	0.	81	317	0.	81	318	0.	81	319	0.	81	320	0.	81
336	0.	0	337	0.	0	338	0.	0	339	0.	81	340	0.	81
341	0.	81	342	0.	81	343	0.	81	344	0.	81	345	0.	81
346	0.	81	347	0.	81	348	0.	81	349	0.	81	350	0.	81
351	0.	81	352	0.	81	353	0.	81	354	0.	81	355	0.	81
356	0.	81	357	0.	0	358	0.	81	359	0.	0	360	0.	0
361	0.	0	362	0.	0	363	0.	0	364	0.	81	365	0.	243
366	0.	81	367	0.	81	368	0.	81	369	0.	81	370	0.	162
371	0.	81	372	0.	81	373	0.	81	374	0.	81	375	0.	81
376	0.	162	377	0.	81	378	0.	81	379	0.	81	380	0.	81
381	0.	0	382	0.	162	383	0.	81	384	0.	0	385	0.	0
396	0.	0	397	0.	0	398	0.	81	399	0.	81	400	0.	81
401	0.	81	402	0.	81	403	0.	81	404	0.	81	405	0.	0
406	0.	81	407	0.	0	408	0.	0	409	0.	81	410	0.	81
411	0.	81	412	0.	81	413	0.	81	414	0.	81	415	0.	81
416	0.	81	417	0.	0	418	0.	0	419	0.	0	420	0.	0
421	0.	0	422	0.	0	423	0.	0	424	0.	81	425	0.	81
426	0.	81	427	0.	81	428	0.	81	429	0.	81	430	0.	81
431	0.	81	432	0.	81	433	0.	81	434	0.	81	435	0.	81
436	0.	81	437	0.	81	438	0.	81	439	0.	81	440	0.	81
441	0.	81	442	0.	81	443	0.	81	444	0.	81	445	0.	243
446	0.	81	447	0.	81	448	0.	81	449	0.	81	450	0.	81
451	0.	81	452	0.	4	453	0.	4	454	0.	4	455	0.	1
456	0.	0	457	0.	0	458	0.	0	459	0.	0	460	0.	81
461	0.	81	462	0.	81	463	0.	81	464	0.	81	465	0.	81
466	0.	81	467	0.	81	468	0.	81	469	0.	81	470	0.	81
471	0.	81	472	0.	81	473	0.	81	474	0.	0	475	0.	0
476	0.	0	477	0.	0	478	0.	0	479	0.	0	480	0.	81
481	0.	81	482	0.	81	483	0.	81	484	0.	81	485	0.	81
486	0.	81	487	0.	81	488	0.	81	489	0.	81	490	0.	0
496	0.	0	497	0.	0	498	0.	0	499	0.	0	500	0.	81
501	0.	81	502	0.	81	503	0.	81	504	0.	81	505	0.	81

506	0,	81	507	0,	81	508	0,	0	509	0,	81	510	0,	81
511	0,	81	512	0,	0	513	0,	0	514	0,	0	515	0,	0
521	0,	0	522	0,	0	523	0,	0	524	0,	0	525	0,	81
526	0,	81	527	0,	81	528	0,	81	529	0,	81	530	0,	81
531	0,	81	532	0,	81	533	0,	0	534	0,	0	535	0,	0
536	0,	0	537	0,	0	538	0,	0	539	0,	0	540	0,	106
541	0,	0	542	0,	0	543	0,	0	544	0,	0	545	0,	106
546	0,	5	547	0,	5	548	0,	5	549	0,	5	550	0,	106

SAVEX	NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE		NR........VALUE	
	1	50	2	60	3	106	4	65	5	80
	6	10	7	3	8	5	9	9660	10	9530
	11	80	12	0	13	0	14	0	15	167
	16	73	17	0	18	0	19	0	20	5
	21	50	22	60	23	106	24	65	25	80
	26	10	27	3	28	5	29	0	30	10
	31	0	32	0	33	0	34	0	35	10
	41	50	42	60	43	106	44	65	45	80
	46	10	47	3	48	5	49	0	50	0
	51	11	52	0	53	0	54	0	55	0
	66	0	67	0	68	0	69	0	70	10
	96	0	97	0	98	0	99	0	100	106
	101	12774	102	12819	103	12830	104	12915	105	130
	106	0	107	0	108	11	109	141	110	106
	111	12830	112	12830	113	12895	114	12895	115	137
	116	12940	117	12940	118	4	119	141	120	12957
	121	0	122	12961	123	12971	124	0	125	0
	126	0	127	0	128	0	129	0	130	106
	131	12873	132	12885	133	12906	134	12940	135	94
	136	12965	137	12965	138	46	139	140	140	12980
	141	0	142	12980	143	13013	144	0	145	0
	146	0	147	0	148	0	149	0	150	106
	151	12958	152	12980	153	13068	154	13068	155	118
	156	13098	157	0	158	22	159	140	160	106
	161	12991	162	13001	163	13068	164	13121	165	73
	166	13121	167	13131	168	67	169	140	170	106
	171	13131	172	13253	173	0	174	0	175	122
	176	0	177	0	178	0	179	122	180	0
	181	106	182	0	183	0	184	0	185	0

FACILITY NR	AVERAGE UTILIZATION	NUMBER ENTRIES	AVERAGE TIME/TRANS	TRANS	$TRANS
1	.8855	106	121.75	0	0
2	.0885	86	15.00	0	0
3	.0590	86	10.00	0	0
4	.0590	86	10.00	0	0
5	.0556	81	10.00	0	0
7	.0000	86	.00	0	0
9	.0590	86	10.00	0	0
10	.0590	86	10.00	0	0
11	.0590	86	10.00	0	0
12	.0590	86	10.00	0	0
20	.8893	106	122.27	0	0
22	.1180	86	20.00	0	0
23	.0278	81	5.00	0	0
24	.0000	86	.00	0	0
25	.1897	86	32.15	0	0

26	.0124	86	2.09	0	0
27	.1180	86	20.00	0	0
28	.0590	86	10.00	0	0
29	.0086	5	25.00	0	0
30	.0069	5	20.00	0	0
35	.0834	81	15.00	0	0
36	.0500	81	9.00	0	0
37	.0556	81	10.00	0	0
45	.8714	81	156.79	0	0
47	.0066	81	1.19	0	0
48	.0556	81	10.00	0	0
49	.0445	81	8.00	0	0
50	.0278	81	5.00	0	0
51	.0945	81	17.00	0	0
52	.0111	81	2.00	0	0
53	.0111	81	2.00	0	0
54	.0167	81	3.00	0	0
55	.0111	81	2.00	0	0
56	.0066	81	1.19	0	0
57	.0167	81	3.00	0	0
58	.0834	81	15.00	0	0
59	.0278	81	5.00	0	0
60	.0445	81	8.00	0	0
61	.0278	81	5.00	0	0
62	.0167	81	3.00	0	0
63	.0556	81	10.00	0	0
64	.0556	81	10.00	0	0
75	.8950	81	161.04	0	0
76	.0278	81	5.00	0	0
77	.0278	81	5.00	0	0
78	.0278	81	5.00	0	0
79	.2223	81	40.00	0	0
80	.0278	81	5.00	0	0
81	.0556	81	10.00	0	0
82	.0278	81	5.00	0	0
95	.8995	81	161.85	0	0
96	.0000	81	.00	0	0
98	.0556	81	10.00	0	0
104	.0556	81	10.00	0	0
105	.0278	81	5.00	0	0
106	.1000	81	18.00	0	0
107	.0556	81	10.00	0	0
108	.0556	81	10.00	0	0
109	.0556	81	10.00	0	0
110	.0556	81	10.00	0	0
112	.0834	81	15.00	0	0
120	.6781	81	122.00	0	0
121	.0111	81	2.00	0	0
122	.0278	81	5.00	0	0
123	.0556	81	10.00	0	0
124	.0278	81	5.00	0	0
125	.0556	81	10.00	0	0
126	.0945	81	17.00	0	0
127	.1389	81	25.00	0	0
128	.0278	81	5.00	0	0
129	.0556	81	10.00	0	0
130	.0278	81	5.00	0	0

131	.0556	81	10.00	0	0
132	.1779	81	32.00	0	0
133	.2779	81	50.00	0	0
134	.0278	81	5.00	0	0
135	.0556	81	10.00	0	0
136	.0278	81	5.00	0	0
137	.0556	81	10.00	0	0
138	.0556	81	10.00	0	0

QUEUE NR	MAXIMUM CONTENTS	AVERAGE CONTENTS	TOTAL ENTRIES	ZERO ENTRIES	ZEROS PERCENT	AVERAGE TIME/ENTRIES ALL ENT	NON ZERO ENT	TABLE NUMBER	CURRENT CONTENTS
1	1	.00	106	106	100.00	.00	.00	0	0
2	3	.40	106	1	.94	55.42	55.94	0	0
3	1	.49	81	6	7.41	89.01	96.12	0	0
4	2	.94	81	2	2.47	169.77	174.00	0	0
5	2	1.12	81	2	2.47	201.95	207.00	0	0
11	1	.00	106	106	100.00	.00	.00	0	0
12	2	1.72	106	4	3.77	237.07	246.30	0	0

FUTURE RANDOM NUMBER SEED IS (OCTAL)   053025301275

APPENDIX III

COMBINED FOREST GROWTH SIMULATION MODEL COMPUTER PROGRAM AND ECONOMIC MODEL COMPUTER PROGRAM WITH SAMPLE PRINTOUT

```
@RUN  ,031A0935,COSBY-WALTER,5,200                                    4016  CR1

@SYM PRINT$,,PR2

@ASG,I 14

@ASG,I 12

@ASG,I 21

@ASG,I 23

@ASG,I 24

@ASG,I 20

@XQT      GT*DYNAMO.DYNAMO

 DYNAMO LEVEL B GEORGIA TECH REV. 1.1

 RUN    1
 NOTE   ****************************************************************
 NOTE   ****************************************************************
 NOTE
 NOTE                    FOREST GROWTH MODEL SECTION OF PROGRAM
 NOTE   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
 NOTE                         SUBPROGRAMS 1 THROUGH 12
 NOTE
 NOTE   ****************************************************************
 NOTE   ****************************************************************
 NOTE   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
 NOTE                                * * SUBPROGRAM 1 * *
 NOTE               SUBPROGRAM FOR ESTABLISHING COMPUTATIONAL CONSTANTS
 NOTE   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
 C      X=1
 C      SITEI=70
 20A    F=1/2.3025851
 C      F=1
```

```
NOTE   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
NOTE                              * * SUBPROGRAM 2 * *
NOTE                 SUBPROGRAM FOR COMPUTING TIME VALUES USED IN THE
NOTE                 PROGRAM
NOTE   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
1L     N.K=N.J+(DT)(+NR-0)
C      NR=1
6N     N=0
7A     N1.K=P+N.K
51A    NC.K=CLIP(+0,1,N.K,+1)
7A     NX.K=N.K+NC.K
6A     AGE.K=NX.K
20A    NIV.K=P/NX.K
7A     XAGE.K=AGE.K+P
NOTE   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
NOTE                              * * SUBPROGRAM 3 * *
NOTE                 SUBPROGRAM FOR COMPUTING TREE DIAMETER AT BREAST
NOTE                 HEIGHT
NOTE   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
29A    DBHB1.K=(F.K)LOGN(XSTAF.K)
12A    DBHB.K=(0.234544)(DBHB1.K)
29A    DBHC1.K=(F.K)LOGN(SITEI.K)
12A    DBHC.K=(0.314215)(DBHC1.K)
12A    DBHA1.K=(AGE.K)(SITEI.K)
12A    DBHA.K=(0.000219)(DBHA1.K)
9A     DBHL.K=+0.650712+DBHA.K-DBHB.K+DBHC.K
12A    DBHL1.K=(2.3025851)(DBHL.K)
28A    DBHT.K=(X.K)EXP(DBHL1.K)
12A    DBH.K=(BASL4.K)(DBHT.K)
NOTE   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
NOTE                              * * SUBPROGRAM 4 * *
NOTE                 SUBPROGRAM COMPUTING TREE HEIGHT
NOTE   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
6A     HGHB.K=DBHC1.K
20A    HGHA2.K=1/25
20A    HGHA3.K=1/AGE.K
7A     HGHA1.K=HGHA2.K-HGHA3.K
12A    HGHA.K=(5.40638)(HGHA1.K)
7A     HGHL.K=HGHB.K+HGHA.K
12A    HGHL1.K=(2.3025851)(HGHL.K)
28A    HGH.K=(X.K)EXP(HGHL1.K)
NOTE   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
NOTE                              * * SUBPROGRAM 5 * *
NOTE                 SUBPROGRAM FOR COMPUTING TREE SURVIVAL
NOTE   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C      TPA=500
52L    HSTPA.K=HSTPA.J+(DT)(RTPA.JK-INMR.JK-AMR.JK-MORT1.JK)
6N     HSTPA=200
52L    MORT.K=MORT.J+(DT)(INMR.JK+AMR.JK+MORT1.JK+0.0)
6N     MORT=0.0
51A    INMN1.K=CLIP(INMN.K,0,N.K,1.0)
51R    INMR.KL=CLIP(0.0,INMN1.K,N.K,2.0)
C      AMPC=0.012
13R    AMR.KL=(HSTPA.K)(BASA3.K)(AMPC)
12A    MORT1.KL=(MORT2.K)(HSTPA.K)
59A    MORT2.K=TABLE(MORT3,N.K,0,40,40)
C      MORT3*=0/0
```

```
7A     TPA2.K=TPA-200
51A    TPA1.K=CLIP(TPA2.K,0,N.K,1.0)
51R    RTPA.KL=CLIP(0.0,TPA1.K,N.K,2.0)
C      INSUP=0.88
7A     INMP.K=1.0-INSUP
12A    INMN.K=(TPA)(INMP.K)
12A    INSN.K=(TPA)(INSUP)
14A    XSTAF.K=HSTPA.K+(MORT.K)(0.2)
6A     STPA1*1.K=XSTAF.K
37B    STPA1.K=BOXLIN(2,1)
C      STPA1*=1/1
7A     STPA2.K=XSTAF.K-STPA1*2.K
51A    STPA6.K=CLIP(STPA2.K,0.0,N.K,3.0)
7A     XSTPA.K=XSTAF.K+STPA6.K
20A    SFFT.K=43560/HSTPA.K
20A    SURP.K=HSTPA.K/TPA
NOTE   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
NOTE                                 * * SUBPROGRAM 6 * *
NOTE                 SUBPROGRAM FOR COMPUTING BASAL AREA
NOTE   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
13A    BASAT.K=(3.1415927)(DBH.K)(DBH.K)
20A    BASAF.K=BASAT.K/4
44A    BASA.K=(BASAF.K)(TPA.K)/144
44A    BASAS.K=(BASAF.K)(XSTAF.K)/144
NOTE   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
NOTE                                 * * SUBPROGRAM 7 * *
NOTE                 SUBPROGRAM FOR COMPUTING THE BASAL AREA AT THE NEXT
NOTE                 YEAR WHEN GROWTH SUPPRESSION OCCURS
NOTE   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
6A     BASA1*1.K=BASAS.K
37B    BASA1.K=BOXLIN(2,1)
C      BASA1*=1/0
7A     BASD2.K=BASAS.K-BASA1*2.K
12A    BAXA2.K=(BASA4.K)(BASD2.K)
7A     BAXA3.K=BASAS.K+BAXA2.K
NOTE   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
NOTE                                 * * SUBPROGRAM 8 * *
NOTE                 SUBPROGRAM FOR COMPUTING D.B.H. SUPPRESSION FACTOR
NOTE                 WHEN SUPPRESSION OCCURS
NOTE   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
20A    BAXA4.K=BAXA3.K/BAXAS.K
51A    BAXA6.K=CLIP(BAXA4.K,0.000001,BAXA4.K,0.000001)
30A    BASL3.K=(1)SQRT(BAXA6.K)
51A    BASL5.K=CLIP(BASL3.K,1.0,BASA3.K,1.0)
6A     BASL6*1.K=BASL5.K
37B    BASL6.K=BOXLIN(2,1)
C      BASL6*=1/1
6A     BASL4.K=BASL6*2.K
NOTE   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
NOTE                                 * * SUBPROGRAM 9 * *
NOTE                 SUBPROGRAM FOR COMPUTING BASAL AREA VALUE AT WHICH
NOTE                 GROWTH SUPPRESSION OCCURS
NOTE   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
12A    BASS1.K=(3.0)(DBH.K)
27A    BASS2.K=(4.0/DBH.K)+DBH.K
20A    BASS3.K=12.0/BASS2.K
29A    BASS4.K=(3.73)LOGN(BASS3.K)
```

```
28A   BASS5.K=(1.0)EXP(BASS4.K)
20A   BASS6.K=DBH.K/11
29A   BASS7.K=(4.5)LOGN(BASS6.K)
28A   BASS8.K=(1)EXP(BASS7.K)
9A    BASS9.K=133+BASS1.K-BASS5.K-BASS8.K
12A   BASA5.K=(BASS9.K)(BAS10.K)
59A   BAS10.K=TABLE(BAS11,SITEI,40,80,40)
C     BAS11*=0.65/1.20
NOTE  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
NOTE                                          * * SUBPROGRAM 10 * *
NOTE                  SUBPROGRAM FOR COMPUTING BASAL AREA INCREASE DURING
NOTE                  THE NEXT COMPUTATIONAL INTERVAL RELATIVE TO BASAL
NOTE                  AREA INCREASE DURING THE PAST COMPUTATIONAL INTERVAL
NOTE                  WHEN GROWTH SUPPRESSION OCCURS
NOTE  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
20A   BASA3.K=BASAS.K/BASA5.K
51A   BAXA9.K=CLIP(BASA3.K,1.0,BASA3.K,1.0)
29A   BAXA7.K=(4.20)LOGN(BAXA9.K)
28A   BAXA8.K=(1)EXP(BAXA7.K)
59A   BASA4.K=TABHL(BASTA,BAXA8.K,1.0,7.00,6.00)
C     BASTA*=1.0/.5
NOTE  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
NOTE                                          * * SUBPROGRAM 11 * *
NOTE                  SUBPROGRAM FOR COMPUTING THE UNSUPPRESSED BASAL AREA
NOTE                  AT THE NEXT COMPUTATIONAL INSTANT
NOTE  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
29A   DBXB1.K=(F)LOGN(XSTPA.K)
12A   DBXB.K=(0.234544)(DBXB1.K)
12A   DBXA1.K=(XAGE.K)(SITEI.K)
12A   DBXA.K=(0.000219)(DBXA1.K)
9A    DBXL.K=+0.650712+DBXA.K-DBXB.K+DBHC.K
12A   DBXL1.K=(2.3025851)(DBXL.K)
28A   DBXT.K=(X)EXP(DBXL1.K)
13A   BAXAT.K=(3.1415927)(DBXT.K)(DBXT.K)
20A   BAXA5.K=BAXAT.K/4
44A   BAXAS.K=(BAXA5.K)(XSTPA.K)/144
NOTE  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
NOTE                                          * * SUBPROGRAM 12 * *
NOTE                  SUBPROGRAM FOR COMPUTING THE YIELD PER ACRE
NOTE  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
13A   VOLF.K=(DBH.K)(DBH.K)(HGH.K)
12A   V3I1.K=(0.002135)(VOLF.K)
7A    V3I2.K=V3I1.K-0.693239
20A   V3ITC.K=72/V3I2.K
44A   V3IWT.K=(V3I2.K)(CDWT)/72
12A   V3I3.K=(TPA.K)(V3I2.K)
12A   V3I4.K=(HSTPA.K)(V3I2.K)
20A   V3I10.K=V3I4.K/72
20A   V3I11.K=V3I10.K/AGE.K
51A   V3I5.K=CLIP(V3I10.K,1,V3I10.K,1)
12A   V3I60.K=(V3I5.K)(V3I70.K)
20A   V3I61.K=V3I60.K/AGE.K
NOTE  ******************************************************************
NOTE  ******************************************************************
NOTE
NOTE                        ECONOMIC MODEL SECTION OF PROGRAM
NOTE  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
```

```
NOTE                        SUBPROGRAMS 13 THROUGH 23
NOTE
NOTE    ******************************************************************
NOTE    ******************************************************************
NOTE    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
NOTE                                * * SUBPROGRAM 13 * *
NOTE                SUBPROGRAM FOR COMPUTING THE HARVESTING COST PER
NOTE                CORD AT HARVESTING TIME
NOTE    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
7A      CCF02.K=+TPA-200
7A      CCF03.K=+TPA-300
7A      CCF04.K=+TPA-400
7A      CCF05.K=+TPA-500
7A      CCF06.K=+TPA-600
7A      CCF07.K=+TPA-700
7A      CCF08.K=+TPA-800
7A      CCF09.K=+TPA-900
7A      CCF10.K=+TPA-1000
49A     CCF12.K=SWITCH(1.0,0.0,CCF02.K)
49A     CCF13.K=SWITCH(1.0,0.0,CCF03.K)
49A     CCF14.K=SWITCH(1.0,0.0,CCF04.K)
49A     CCF15.K=SWITCH(1.0,0.0,CCF05.K)
49A     CCF16.K=SWITCH(1.0,0.0,CCF06.K)
49A     CCF17.K=SWITCH(1.0,0.0,CCF07.K)
49A     CCF18.K=SWITCH(1.0,0.0,CCF08.K)
49A     CCF19.K=SWITCH(1.0,0.0,CCF09.K)
49A     CCF20.K=SWITCH(1.0,0.0,CCF10.K)
58A     CCF22.K=TABHL(CCF32,SURP.K,0.5,1.0,0.05)
C       CCF32*=27.2/25.4/23.9/22.612/21.583/20.698/19.888/19.0/18.3/17.6/1
X1      7.0
58A     CCF23.K=TABHL(CCF33,SURP.K,0.5,1.0,0.05)
C       CCF33*=24.5/23.0/21.7/20.600/19.691/18.900/18.201/17.4/16.8/16.2/1
X1      5.6
58A     CCF24.K=TABHL(CCF34,SURP.K,0.5,1.0,0.05)
C       CCF34*=22.6/21.4/20.3/19.371/18.540/17.827/17.198/16.5/16.0/15.4/1
X1      4.9
58A     CCF25.K=TABHL(CCF35,SURP.K,0.5,1.0,0.05)
C       CCF35*=21.7/20.5/19.4/18.523/17.750/17.088/16.503/15.9/15.4/14.9/1
X1      4.5
58A     CCF26.K=TABHL(CCF36,SURP.K,0.5,1.0,0.05)
C       CCF36*=20.6/19.6/18.6/17.886/17.160/16.536/15.984/15.4/14.9/14.4/1
X1      4.0
58A     CCF27.K=TABHL(CCF37,SURP.K,0.5,1.0,0.05)
C       CCF37*=20.1/19.1/18.1/17.395/16.701/16.108/15.585/15.0/14.6/14.1/1
X1      3.7
58A     CCF28.K=TABHL(CCF38,SURP.K,0.5,1.0,0.05)
C       CCF38*=19.6/18.7/17.7/17.023/16.359/15.791/15.289/14.7/14.3/13.9/1
X1      3.5
58A     CCF29.K=TABHL(CCF39,SURP.K,0.5,1.0,0.05)
C       CCF39*=19.2/18.3/17.4/16.697/16.054/15.505/15.020/14.5/14.1/13.7/1
X1      3.3
58A     CCF30.K=TABHL(CCF40,SURP.K,0.5,1.0,0.05)
C       CCF40*=18.9/18.0/17.1/16.446/15.824/15.292/14.821/14.3/13.9/13.6/1
X1      3.2
12A     CCF42.K=(CCF12.K)(CCF22.K)
12A     CCF43.K=(CCF13.K)(CCF23.K)
12A     CCF44.K=(CCF14.K)(CCF24.K)
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```
12A     CCF45.K=(CCF15.K)(CCF25.K)
12A     CCF46.K=(CCF16.K)(CCF26.K)
12A     CCF47.K=(CCF17.K)(CCF27.K)
12A     CCF48.K=(CCF18.K)(CCF28.K)
12A     CCF49.K=(CCF19.K)(CCF29.K)
12A     CCF50.K=(CCF20.K)(CCF30.K)
8A      CCF51.K=+CCF42.K+CCF43.K+CCF44.K
10A     CCF52.K=+CCF45.K+CCF46.K+CCF47.K+CCF48.K+CCF49.K+CCF50.K
7A      CCF53.K=+CCF51.K+CCF52.K
51A     CCF60.K=CLIP(+0.0,1.0,SLRP.K,0.675)
58A     CCF61.K=TABHL(CCF62,DPH.K,4.0,12.0,1.0)
C       CCF62*=-0.354/+0.000/+0.354/+0.817/+1.179/+1.539/+2.433/+3.327/+4.
X1      221
12A     CCF63.K=(CCF60.K)(CCF61.K)
51A     CCF64.K=CLIP(+1.0,0.0,SLRP.K,0.675)
51A     CCF65.K=CLIP(-1.0,0.0,SLRP.K,0.725)
58A     CCF66.K=TABHL(CCF67,DPH.K,4.0,12.0,1.0)
C       CCF67*=-0.343/+0.000/+0.343/+0.795/+1.145/+1.493/+2.369/+3.245/+4.
X1      121
18A     CCF68.K=(CCF66.K)(CCF64.K+CCF65.K)
51A     CCF69.K=CLIP(+1.0,0.0,SLRP.K,0.725)
51A     CCF70.K=CLIP(-1.0,0.0,SLRP.K,0.775)
58A     CCF71.K=TABHL(CCF72,DPH.K,4.0,12.0,1.0)
C       CCF72*=-0.333/+0.000/+0.333/+0.775/+1.115/+1.453/+2.313/+3.173/+4.
X1      033
18A     CCF73.K=(CCF71.K)(CCF69.K+CCF70.K)
51A     CCF74.K=CLIP(+1.0,0.0,SLRP.K,0.775)
58A     CCF75.K=TABHL(CCF76,DPH.K,4.0,12.0,1.0)
C       CCF76*=-0.325/+0.000/+0.325/+0.758/+1.089/+1.419/+2.265/+3.111/+3.
X1      957
12A     CCF77.K=(CCF75.K)(CCF74.K)
9A      CCF78.K=+CCF63.K+CCF68.K+CCF73.K+CCF77.K
7A      CCF79.K=CCF53.K+CCF78.K
20A     VITC.K=V3ITC.K/+V3170.K
12A     CCF80.K=(VITC.K)(CCPL.K)
12A     CCF81.K=(CCF80.K)(CCF79.K)
58A     CCF82.K=TABHL(CCF83,DPH.K,0.0,12.0,1.0)
C       CCF83*=28.20/28.20/28.20/28.20/28.20/28.20/28.20/28.80/29.30/29.70
X1      /32.20/30.73/31.32
7A      CCF84.K=CCF81.K-CCF82.K
C       TWTI1=3
C       BUPT1=10
C       LMTI1=2
C       IGCT1=1
C       TWTI2=6
C       RMTI1=4
10A     CCF85.K=+TWTI1.K+BUPT1.K+LMTI1.K+IGCT1.K+TWTI2.K+RMTI1.K
58A     CCF86.K=MAX(+CCF85.K,+CCF82.K)
C       BUPT2=4
C       TWTI3=6
C       IRGCT=1
C       PFWT1=14
C       ILGCT=1
10A     CCF87.K=+CCF86.K+BUPT2.K+TWTI3.K+IRGCT.K+PFWT1.K+ILGCT.K
7A      CCF88.K=CCF87.K+CCF84.K
20A     V3I14.K=CCF88.K/60
51A     CCF89.K=CLIP(CCF80.K,1.0,CCF80.K,1.0)
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```
20A   CCF90.K=CCF88.K/CCF89.K
58A   V3I70.K=TABHL(V3I71,HGH.K,65,100,1)
C     V3I71*=1/.9966/.9957/.9922/.9894/.9865/.9837/.9805/.9774/.9742/.97
X1    10/.9676/.9642/.9608/.9574/.9531/.9503/.9466/.9429/.9396/.9355/.93
X2    21/.9277/.9242/.9206/.9167/.9130/.9089/.9052/.9019/.8977/.8938/.89
X3    02/.8861/.8825/.8780
44A   V3I15.K=(E5.K)(V3I14.K)/60
20A   V3I16.K=V3I15.K/CDPL.K
20A   V3I62.K=V3I16.K/C5.K
C     CDWT=5400
C     LOAD=13000
20A   CDPL.K=LOAD.K/CDWT.K
NOTE  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
NOTE                                        * * SUBPROGRAM 14 * *
NOTE                  SUBPROGRAM FOR COMPUTING THE VALUE, AT PLANTING
NOTE                  TIME, OF ALL EXPENSES RELATED TO PLANTING AND
NOTE                  GROWING THE FOREST
NOTE  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
10A   INV.K=+ILV+SPPC.K+H3.K+H4.K+SPC1+0.0
6A    ILV.K=TE1B2.K
C     SPC1=20
8A    SPPC.K=SPC+TC.K+PC.K
C     SPC=12
44A   TC.K=(TPA)(TCPT.K)/1000
C     TCPT=4
44A   PC.K=(TPA)(PCPT.K)/1000
C     PCPT=15
NOTE  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
NOTE                                        * * SUBPROGRAM 15 * *
NOTE                  SUBPROGRAM FOR COMPUTING THE LAND VALUE AT 1 YEAR
NOTE                  INCREMENTS AFTER PLANTING
NOTE  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C     I1=.03
7A    A1.K=P+I1
29A   B1.K=(N.K)LOGN(+A1.K)
28A   C1.K=(P)EXP(B1.K)
51A   D1.K=CLIP(+C1.K,+P,+LCCT,+5)
12A   E1.K=(D1.K)(TE1.K)
12A   TE1.K=(TE1B1.K)(TE1B2.K)
59A   TE1B1.K=TABLE(TE1V1,N.K,0,40,40)
C     TE1V1*=1/1
59A   TE1B2.K=TABLE(TE1V2,SITEI.K,40,80,10)
C     TE1V2*=50/60/70/80/90
C     LCCT=10
NOTE  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
NOTE                                        * * SUBPROGRAM 16 * *
NOTE                  SUBPROGRAM FOR COMPUTING THE STUMPAGE PRICE AT 1
NOTE                  YEAR INCREMENTS AFTER PLANTING
NOTE  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C     I2=.03
7A    A2.K=P+I2
29A   B2.K=(N.K)LOGN(+A2.K)
28A   C2.K=(P)EXP(B2.K)
51A   D2.K=CLIP(+C2.K,+P,+SPCT,+5)
12A   E2.K=(D2.K)(TE2.K)
12A   TE2.K=(TE2B1.K)(TE2B2.K)
59A   TE2B1.K=TABLE(TE2V1,N.K,0,40,40)
```

```
C       TE2V1*=1/1
C       TE2B2=8.00
C       SPCT=10
NOTE    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
NOTE                                    * * SUBPROGRAM 17 * *
NOTE                 SUBPROGRAM FOR COMPUTING THE ANNUAL TAXES AT 1 YEAR
NOTE                 INCREMENTS AFTER PLANTING
NOTE    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C       I3=.03
7A      A3.K=P+I3
29A     B3.K=(N.K)LOGN(+A3.K)
28A     C3.K=(P)EXP(B3.K)
51A     D3.K=CLIP(+C3.K,P,+TRCT,+5)
12A     E3.K=(D3.K)(TE3.K)
12A     TE3.K=(TE3B1.K)(TE3B2.K)
59A     TE3B1.K=TABLE(TE3V1,N.K,0,40,40)
C       TE3V1*=1/1
58A     TE3B2.K=TABHL(TE3V2,V3I4.K,500,4000,250)
C       TE3V2*=0.50/1/1/1/1/1/1/1/1/1/1/1/1/1/1.50
12R     F3.KL=(E3.K)(D10.K)
1L      H3.K=H3.J+(DT)(+F3.JK+0)
6N      H3=0
C       TRCT=10
NOTE    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
NOTE                                    * * SUBPROGRAM 18 * *
NOTE                 SUBPROGRAM FOR COMPUTING THE ANNUAL MANGEMENT COSTS
NOTE                 AT 1 YEAR INCREMENTS AFTER PLANTING
NOTE    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C       I4=.03
7A      A4.K=P+I4
29A     B4.K=(N1.K)LOGN(+A4.K)
28A     C4.K=(P)EXP(B4.K)
51A     D4.K=CLIP(+C4.K,P,+MCCT,+5)
12A     E4.K=(D4.K)(TE4.K)
12A     TE4.K=(TE4B1.K)(TE4B2.K)
59A     TE4B1.K=TABLE(TE4V1,N1.K,1,41,40)
C       TE4V1*=1/1
C       TE4B2.K=1.50
C       MCCT=10
12A     F4*1.K=(E4.K)(D10.K)
37B     F4.K=BOXLIN(2,1)
C       F4*=1.50/1.50
6R      G4.KL=F4*2.K
1L      H4.K=H4.J+(DT)(+G4.JK+0)
6N      H4=0
NOTE    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
NOTE                                    * * SUBPROGRAM 19 * *
NOTE                 SUBPROGRAM FOR COMPUTING THE HOURLY OPERATING COST
NOTE                 OF THE HARVESTER AT 1 YEAR INCREMENTS AFTER PLANTING
NOTE    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C       I5=.03
7A      A5.K=P+I5
29A     B5.K=(N.K)LOGN(A5.K)
28A     C5.K=(P)EXP(B5.K)
51A     D5.K=CLIP(+C5.K,P,MOCT,+5)
12A     E5.K=(D5.K)(TE5.K)
12A     TE5.K=(TE5B1.K)(TE5B2.K)
```

```
59A     TE5B1.K=TABLE(TE5V1,N.K,0,40,40)
C       TE5V1*=1/1
C       TE5B2=30.00
C       MOCT=10
NOTE    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
NOTE                          * * SUBPROGRAM 20 * *
NOTE                 SUBPROGRAM FOR COMPUTING THE HARVESTING COST
NOTE                 ALLOWANCE AT 1 YEAR INCREMENTS AFTER PLANTING
NOTE    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
12A     TE6.K=(TE6B1.K)(TE6B2.K)
59A     TE6B1.K=TABLE(TE6V1,N.K,0,40,40)
C       TE6V1*=1/1
C       TE6B2=1.50
51A     D6.K=CLIP(+C5.K,P,HCCT,+5)
12A     E6.K=(D6.K)(TE6.K)
C       HCCT=10
NOTE    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
NOTE                          * * SUBPROGRAM 21 * *
NOTE                 SUBPROGRAM FOR COMPUTING DISCOUNT FACTORS FOR
NOTE                 FOLLOW-ON EXPENSES WHICH ARE INVESTED UNTIL REQUIRED
NOTE    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C       I10=.05
7A      A10.K=P+I10
29A     B10.K=(N1.K)LOGN(+A10.K)
28A     C10.K=(P)EXP(B10.K)
20A     D10.K=P/C10.K
NOTE    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
NOTE                          * * SUBPROGRAM 22 * *
NOTE                 SUBPROGRAM FOR COMPUTING THE RATE OF RETURN FOR THE
NOTE                 INDEPENDENT LANDOWNER AT 1 YEAR INCREMENTS AFTER
NOTE                 PLANTING
NOTE    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
7A      V3I21.K=V3I16.K-E6.K
7A      V3I22.K=E2.K-V3I21.K
12A     V3I23.K=(V3I22.K)(V3I60.K)
7A      V3I24.K=E1.K+V3I23.K
7A      V3I25.K=V3I24.K-INV.K
20A     V3I26.K=V3I25.K/NX.K
20A     V3I27.K=V3I24.K/INV.K
51A     V3I32.K=CLIP(V3I27.K,1.0,V3I27.K,1.0)
29A     V3I28.K=(NIV.K)LOGN(V3I32.K)
28A     V3I29.K=(P)EXP(V3I28.K)
7A      V3I30.K=V3I29.K-P
NOTE    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
NOTE                          * * SUBPROGRAM 23 * *
NOTE                 SUBPROGRAM COMPUTES THE WOOD GROWING COST FOR THE
NOTE                 PAPER COMPANY AT 1 YEAR INCREMENTS AFTER PLANTING
NOTE    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
6R      K3.KL=E3.K
1L      CWC1.K=CWC1.J+(DT)(K3.JK+0)
6N      CWC1=0
6R      K4.KL=E4.K
1L      CWC2.K=CWC2.J+(DT)(K4.JK+0)
6N      CWC2=1.50
6A      CWC4*1.K=CWC2.K
37B     CWC4.K=BOXLIN(2,1)
C       CWC4*=0/0
```

```
7A      CWC5.K=CWC1.K+CWC2.K
8A      CWC6.K=ILV.K+SPPC.K+SPC1.K
8A      CWC7.K=CWC6.K+CWC5.K+CWC11.K
12R     CWC9.KL=(CWC8.K)(CWC7.K)
C       CWC8=.06
1L      CWC11.K=CWC11.J+(DT)(CWC9.JK+0)
6N      CWC11=0
10A     CWC12.K=CWC6.K+CWC4*2.K+CWC1.K+CWC11.K-E1.K+0
20A     CWC13.K=CWC12.K/V3I60.K
7A      CWC14.K=CWC13.K+V3I21.K
NOTE    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
NOTE    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
PRINT   1)AGE,TPA,SURP,SITEI
PRINT   2)V3I30,CWC14
PRINT   3)DBH,DBHT,HGH
PRINT   4)V3IWT,BASAS,V3I61,BASA4
PRINT   5)V3I60,V3I5,CCF80
PRINT   6)CCF88,CCF90,CCF80
PRINT   7)V3I16,V3I62,E6
PRINT   8)E2,E3,E4,E1
PRINT   9)INV,ILV,SPC1,SPPC
PRINT   10)V3I24,CWC12,CWC11
PLOT    V3I30=X(0.05,0.11)
PLOT    CWC14=X(4,16)
PLOT    HGH=X(0,100)
PLOT    SURP=X(0.4,1.0)
PLOT    DBH=X(0,20)
PLOT    BASAS=X(100,300)
PLOT    V3I61=X(1.5,3.5)
PLOT    V3IWT=X(0,4000)
SPEC    DT=1/LENGTH=40/PRTPER=1/PLTPER=1
END
```

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TIME	AGE	V3I3D	CPF	V3IWT	V3I60	CCF88	V3I16	E2	INV	V3I24
	TPA	CWC14	CPFT	PASAS	V3I5	CCF90	V3I62	E3	ILV	CWC12
	SURF		FGF	V3IF1	CCF80	CCF80	E6	E4	SPC1	CWC11
	SITEI			PASA4				E1	SPPC	
.0000	.10000+01	.00000	.50828+01	-.51991+02	.10000+01	-.54073+04	-.16717+02	.80000+01	.12150+03	.10822+03
	.50000+03	.21283+02	.50828+01	.28182+02	.10000+01	-.54073+04	-.16717+02	.50000+00	.80000+02	.41500+02
	.40000+00		.45183-03	.10000+01	-.25004+03	-.25004+03	.10000+01	.15450+01	.20000+02	.00000
	.70000+02			.10000+01				.80000+02	.21500+02	
.1000+01	.10000+01	.00000	.50851+01	-.51991+02	.10000+01	-.54075+04	-.15280+02	.82400+01	.12348+03	.11146+03
	.50000+03	.27655+02	.50851+01	.28153+02	.10000+01	-.54075+04	-.16718+02	.51500+00	.80000+02	.48480+02
	.39905+00		.45183-03	.10000+01	-.25004+03	-.25004+03	.15450+01	.15913+01	.20000+02	.73800+01
	.70000+02			.10000+01				.82400+02	.21500+02	
.2000+01	.20000+01	.00000	.43506+01	-.51302+02	.10000+01	-.38784+04	-.14243+02	.84872+01	.12541+03	.10919+03
	.50000+03	.40179+02	.43506+01	.46585+02	.10000+01	-.38784+04	-.15425+02	.53045+00	.80000+02	.56014+02
	.87810+00		.22812+00	.50000+00	-.25340+03	-.25340+03	.15913+01	.16391+01	.20000+02	.15325+02
	.70000+02			.10000+01				.84872+02	.21500+02	
.3000+01	.30000+01	.00000	.45104+01	-.46076+02	.10000+01	-.43464+04	-.16440+02	.87418+01	.12732+03	.11424+03
	.50000+03	.46059+02	.45104+01	.49905+02	.10000+01	-.43464+04	-.15045+02	.54636+00	.80000+02	.64138+02
	.87439+00		.16165+01	.33333+00	-.28214+03	-.28214+03	.16391+01	.16863+01	.20000+02	.23874+02
	.70000+02			.10000+01				.87418+02	.21500+02	
.4000+01	.40000+01	.00000	.46763+01	-.34045+02	.10000+01	-.59270+04	-.24091+02	.90041+01	.12918+03	.12382+03
	.50000+03	.48113+02	.46763+01	.53457+02	.10000+01	-.59270+04	-.20516+02	.56275+00	.80000+02	.72852+02
	.87050+00		.51258+01	.25000+00	-.38185+03	-.38185+03	.16883+01	.17389+01	.20000+02	.33066+02
	.70000+02			.10000+01				.90041+02	.21500+02	
.5000+01	.50000+01	.33759-01	.48485+01	-.16039+02	.10000+01	-.12688+05	-.54915+02	.92742+01	.13101+03	.15467+03
	.50000+03	.29665+02	.48485+01	.57257+02	.10000+01	-.12688+05	-.45920+02	.57964+00	.80000+02	.82319+02
	.86643+00		.95516+01	.20000+00	-.81051+03	-.81051+03	.17389+01	.17911+01	.20000+02	.42943+02
	.70000+02			.10000+01				.92742+02	.21500+02	
.6000+01	.60000+01	.00000	.50272+01	.65395+01	.10000+01	.31410+05	.14982+03	.95524+01	.13281+03	-.22957+02
	.50000+03	.22050+03	.50272+01	.61320+02	.10000+01	.15800+02	.16673+03	.59703+00	.80000+02	.92464+02
	.86216+00		.14464+02	.16667+00	.19879+04	.19879+04	.17911+01	.18448+01	.20000+02	.53551+02
	.70000+02			.10000+01				.95524+02	.21500+02	
.7000+01	.70000+01	.00000	.52127+01	.32652+02	.25931+01	.63533+04	.27048+02	.98390+01	.13457+03	.58551+02
	.50000+03	.65068+02	.52127+01	.65665+02	.25931+01	.15958+02	.24592+02	.61494+00	.80000+02	.10337+03
	.85768+00		.19454+02	.37044+00	.39813+03	.39813+03	.18448+01	.19002+01	.20000+02	.64938+02
	.70000+02			.10000+01				.98390+02	.21500+02	
.8000+01	.80000+01	.00000	.54054+01	.61684+02	.48717+01	.33985+04	.14502+02	.10134+02	.13629+03	.87370+02
	.50000+03	.36628+02	.54054+01	.70309+02	.48717+01	.16125+02	.14764+02	.63338+00	.80000+02	.11510+03
	.85297+00		.24297+02	.60897+00	.21075+03	.21075+03	.19002+01	.19572+01	.20000+02	.77154+02
	.70000+02			.10000+01				.10134+03	.21500+02	
.9000+01	.90000+01	.00000	.56055+01	.93331+02	.73284+01	.22714+04	.16259+02	.10438+02	.13799+03	.12004+03
	.50000+03	.25726+02	.56055+01	.75272+02	.73284+01	.16307+02	.76626+01	.72453+00	.80000+02	.12769+03
	.84803+00		.28883+02	.81427+00	.13929+03	.13929+03	.19572+01	.20159+01	.20000+02	.90255+02
	.70000+02			.10000+01				.10438+03	.21500+02	
.1000+02	.10000+02	.11516-01	.58134+01	.12749+03	.99497+01	.16830+04	.74294+01	.10751+02	.13970+03	.15664+03
	.50000+03	.20013+02	.58134+01	.80575+02	.99497+01	.16506+02	.54258+01	.12535+01	.80000+02	.14128+03
	.84284+00		.33168+02	.99497+00	.10197+03	.10197+03	.20159+01	.20764+01	.20000+02	.10430+03
	.70000+02			.10000+01				.10751+03	.21500+02	
.1100+02	.11000+02	.30639-01	.60293+01	.16421+03	.12732+02	.13235+04	.64418+01	.11074+02	.14167+03	.19742+03
	.50000+03	.16549+02	.60293+01	.86240+02	.12732+02	.16718+02	.45815+01	.13642+01	.80000+02	.15638+03
	.83738+00		.37142+02	.11575+01	.79167+02	.79167+02	.20764+01	.21386+01	.20000+02	.11935+03
	.70000+02			.10000+01				.11074+03	.21500+02	
.1200+02	.12000+02	.44641-01	.62537+01	.20360+03	.15678+02	.10831+04	.54455+01	.11406+02	.14365+03	.24261+03

TIME	AGE	V3I30	DBH	V3IWT	V3I60	CCF66	V3I16	E2	INV	V3I24
	TPA	CWC14	DBHT	BASAS	V315	CCF90	V3I62	E3	ILV	CWC12
	SURF		HGH	V3I61	CCF60	CCF80	E6	E4	SFC1	CWC11
	SITEI			BASA4				E1	SFFC	
	.50000+03	.14220+02	.62537+01	.92288+02	.15678+02	.16963+02	.37492+01	.14258+01	.80000+02	.17267+03
	.83164+00		.40815+02	.13065+01	.63849+02	.63849+02	.24386+01	.22028+01	.20000+02	.13550+03
	.70000+02			.10000+01				.11406+03	.21500+02	
.1300+02	.13000+02	.55184-01	.64869+01	.24587+03	.18795+02	.91058+03	.46288+01	.11748+02	.14560+03	.29270+03
	.50000+03	.12542+02	.64869+01	.98746+02	.18795+02	.17222+02	.34520+01	.14685+01	.80000+02	.19014+03
	.82561+00		.44206+02	.14458+01	.52874+02	.52874+02	.24028+01	.22689+01	.20000+02	.15283+03
	.70000+02			.10000+01				.11748+03	.21500+02	
.1400+02	.14000+02	.63258-01	.67293+01	.29123+03	.22093+02	.78088+03	.46686+01	.12101+02	.14751+03	.34814+03
	.50000+03	.11274+02	.67293+01	.10564+03	.22093+02	.17494+02	.27031+01	.15126+01	.80000+02	.20888+03
	.81928+00		.47335+02	.15780+01	.44638+02	.44638+02	.24089+01	.23370+01	.20000+02	.17142+03
	.70000+02			.10000+01				.12101+03	.21500+02	
.1500+02	.15000+02	.69537-01	.69813+01	.33998+03	.25581+02	.67989+03	.34666+01	.12464+02	.14938+03	.40946+03
	.50000+03	.10280+02	.69813+01	.11299+03	.25581+02	.17761+02	.24535+01	.15580+01	.80000+02	.22896+03
	.81262+00		.50226+02	.17054+01	.38237+02	.38237+02	.24070+01	.24071+01	.20000+02	.19135+03
	.70000+02			.10000+01				.12464+03	.21500+02	
.1600+02	.16000+02	.74489-01	.72433+01	.39242+03	.29273+02	.59824+03	.34231+01	.12838+02	.15122+03	.47735+03
	.50000+03	.94724+01	.72433+01	.12083+03	.29273+02	.16059+02	.24708+01	.16047+01	.80000+02	.25047+03
	.80562+00		.52900+02	.18295+01	.33127+02	.33127+02	.24071+01	.24793+01	.20000+02	.21270+03
	.70000+02			.10000+01				.12838+03	.21500+02	
.1700+02	.17000+02	.78429-01	.75159+01	.44891+03	.33180+02	.53140+03	.34403+01	.13223+02	.15302+03	.55235+03
	.50000+03	.88040+01	.75159+01	.12919+03	.33180+02	.18350+02	.16395+01	.16528+01	.80000+02	.27350+03
	.79827+00		.55377+02	.19518+01	.28959+02	.28959+02	.24793+01	.25536+01	.20000+02	.23558+03
	.70000+02			.10000+01				.13223+03	.21500+02	
.1800+02	.18000+02	.81589-01	.77994+01	.50981+03	.37318+02	.47572+03	.24034+01	.13619+02	.15479+03	.63512+03
	.50000+03	.82396+01	.77994+01	.13809+03	.37318+02	.16656+02	.16467+01	.17024+01	.80000+02	.29816+03
	.79055+00		.57676+02	.20732+01	.25500+02	.25500+02	.25536+01	.26303+01	.20000+02	.26007+03
	.70000+02			.10000+01				.13619+03	.21500+02	
.1900+02	.19000+02	.84136-01	.80945+01	.57555+03	.41698+02	.42869+03	.26021+01	.14028+02	.15653+03	.72640+03
	.50000+03	.77551+01	.80945+01	.14758+03	.41698+02	.18980+02	.14639+01	.17535+01	.80000+02	.32455+03
	.78245+00		.59815+02	.21946+01	.22587+02	.22587+02	.26303+01	.27092+01	.20000+02	.28629+03
	.70000+02			.10000+01				.14028+03	.21500+02	
.2000+02	.20000+02	.86191-01	.84016+01	.64658+03	.46336+02	.36908+03	.24325+01	.14449+02	.15823+03	.82681+03
	.50000+03	.73366+01	.84016+01	.15769+03	.46336+02	.19352+02	.16468+01	.18061+01	.80000+02	.35277+03
	.77396+00		.61807+02	.23168+01	.20106+02	.20106+02	.27092+01	.27904+01	.20000+02	.31433+03
	.70000+02			.10000+01				.14449+03	.21500+02	
.2100+02	.21000+02	.87874-01	.87213+01	.72340+03	.51245+02	.35433+03	.24617+01	.14882+02	.15990+03	.93754+03
	.50000+03	.69642+01	.87213+01	.16844+03	.51245+02	.19717+02	.14265+01	.18603+01	.80000+02	.38295+03
	.76506+00		.63666+02	.24402+01	.17971+02	.17971+02	.27904+01	.28742+01	.20000+02	.34433+03
	.70000+02			.99441+00				.14882+03	.21500+02	
.2200+02	.22000+02	.88956-01	.90344+01	.80281+03	.56100+02	.32604+03	.24625+01	.15329+02	.16152+03	.10532+04
	.50000+03	.66896+01	.90542+01	.17909+03	.56177+02	.20107+02	.14286+01	.28742+01	.80000+02	.41521+03
	.75573+00		.65405+02	.25500+01	.16215+02	.16215+02	.28742+01	.29604+01	.20000+02	.37640+03
	.70000+02			.97188+00				.15329+03	.21500+02	
.2300+02	.23000+02	.89366-01	.93361+01	.88369+03	.60765+02	.30505+03	.24640+01	.15789+02	.16345+03	.11705+04
	.50000+03	.65398+01	.94009+01	.18940+03	.61034+02	.20642+02	.16659+01	.29604+01	.80000+02	.45064+03
	.74602+00		.67034+02	.26419+01	.14778+02	.14778+02	.29604+01	.30492+01	.20000+02	.41069+03
	.70000+02			.94638+00				.15789+03	.21500+02	
.2400+02	.24000+02	.89292-01	.96215+01	.96432+03	.65095+02	.26812+03	.24274+01	.16262+02	.16533+03	.12877+04
	.50000+03	.64829+01	.97619+01	.19912+03	.65711+02	.21172+02	.93735+00	.30492+01	.80000+02	.48851+03

PAGE 3

TIME	AGE / TPA / SURF / SITEI	V3120 / CWC14	DBH / DBHT / FGH	V3IVT / PASAS / V3IF1 / PASA4	V3160 / V315 / CCF80	CCF88 / CCF90 / CCF80	V3116 / V3162 / E6	E2 / E3 / E4 / E1	INV / ILV / SFC1 / SFFC	V3I24 / CWC12 / CWC11
	.73594+00		.66563+02	.27123+01	.13609+02	.13609+02	.30492+01	.31407+01	.20000+02	.44738+03
	.70000+02			.91873+00				.16262+03	.21500+02	
.2500+02	.25000+02	.88506-01	.96862+01	.10435+04	.69159+02	.27385+03	.15648+01	.16750+02	.16718+03	.14059+04
	.50000+03	.64930+01	.10138+02	.20802+03	.70105+02	.21686+02	.94795+00	.31407+01	.80000+02	.52898+03
	.72555+00		.70000+02	.27663+01	.12628+02	.12628+02	.31407+01	.32349+01	.20000+02	.48663+03
	.70000+02			.89017+00				.16750+03	.21500+02	
.2600+02	.26000+02	.88211-01	.10127+02	.11158+04	.72837+02	.26269+03	.15610+01	.17253+02	.16895+03	.15219+04
	.50000+03	.65823+01	.10529+02	.21591+03	.74129+02	.24234+02	.90930+00	.32349+01	.80000+02	.57222+03
	.71492+00		.71354+02	.28014+01	.11815+02	.11815+02	.32349+01	.33319+01	.20000+02	.52861+03
	.70000+02			.86212+00				.17253+03	.21500+02	
.2700+02	.27000+02	.87264-01	.10343+02	.11922+04	.76057+02	.25294+03	.15449+01	.17770+02	.17077+03	.16348+04
	.50000+03	.67435+01	.10936+02	.22269+03	.77725+02	.22699+02	.87055+00	.33319+01	.80000+02	.61839+03
	.70409+00		.72630+02	.28169+01	.11143+02	.11143+02	.33319+01	.34319+01	.20000+02	.57348+03
	.70000+02			.83596+00				.17770+03	.21500+02	
.2800+02	.28000+02	.86119-01	.10534+02	.12600+04	.78824+02	.24503+03	.15406+01	.18303+02	.17251+03	.17433+04
	.50000+03	.69794+01	.11360+02	.22834+03	.80868+02	.23149+02	.84619+00	.34319+01	.80000+02	.66769+03
	.69315+00		.73836+02	.28151+01	.10585+02	.10585+02	.34319+01	.35348+01	.20000+02	.62145+03
	.70000+02			.81275+00				.18303+03	.21500+02	
.2900+02	.29000+02	.84826-01	.10702+02	.13231+04	.81150+02	.23859+03	.15462+01	.18853+02	.17422+03	.18473+04
	.50000+03	.72877+01	.11800+02	.23292+03	.83567+02	.23580+02	.82588+00	.35348+01	.80000+02	.72031+03
	.68214+00		.74977+02	.27983+01	.10118+02	.10118+02	.35348+01	.36409+01	.20000+02	.67270+03
	.70000+02			.79311+00				.18853+03	.21500+02	
.3000+02	.30000+02	.83419-01	.10850+02	.13816+04	.83056+02	.23404+03	.15664+01	.19418+02	.17590+03	.19460+04
	.50000+03	.76743+01	.12259+02	.23655+03	.85854+02	.24062+02	.84013+00	.36409+01	.80000+02	.77647+03
	.67112+00		.76057+02	.27685+01	.97263+01	.97263+01	.36409+01	.37501+01	.20000+02	.72744+03
	.70000+02			.77717+00				.19418+03	.21500+02	
.3100+02	.31000+02	.81968-01	.10980+02	.14360+04	.84610+02	.22956+03	.15667+01	.20001+02	.17754+03	.20415+04
	.50000+03	.81217+01	.12735+02	.23939+03	.87777+02	.24444+02	.79464+00	.37501+01	.80000+02	.83638+03
	.66014+00		.77082+02	.27294+01	.93915+01	.93915+01	.37501+01	.38626+01	.20000+02	.78590+03
	.70000+02			.76471+00				.20001+03	.21500+02	
.3200+02	.32000+02	.80495-01	.11096+02	.14870+04	.85867+02	.22577+03	.20124+01	.20601+02	.17915+03	.21338+04
	.50000+03	.86344+01	.13230+02	.24156+03	.89388+02	.24806+02	.76150+00	.38626+01	.80000+02	.90029+03
	.64924+00		.78056+02	.26834+01	.91011+01	.91011+01	.38626+01	.39785+01	.20000+02	.84831+03
	.70000+02			.75529+00				.20601+03	.21500+02	
.3300+02	.33000+02	.79024-01	.11202+02	.15350+04	.86879+02	.22266+03	.20443+01	.21219+02	.18074+03	.22237+04
	.50000+03	.92128+01	.13744+02	.24322+03	.90739+02	.25173+02	.77076+00	.39785+01	.80000+02	.96844+03
	.63844+00		.78981+02	.26327+01	.88456+01	.88456+01	.39785+01	.40979+01	.20000+02	.91492+03
	.70000+02			.74839+00				.21219+03	.21500+02	
.3400+02	.34000+02	.77551-01	.11299+02	.15806+04	.87620+02	.22011+03	.20614+01	.21855+02	.18229+03	.23102+04
	.50000+03	.98657+01	.14278+02	.24448+03	.91874+02	.25522+02	.76190+00	.40979+01	.80000+02	.10411+04
	.62777+00		.79862+02	.25771+01	.86242+01	.86242+01	.40979+01	.42208+01	.20000+02	.98599+03
	.70000+02			.74351+00				.21855+03	.21500+02	
.3500+02	.35000+02	.76148-01	.11390+02	.16243+04	.88297+02	.21762+03	.21197+01	.22511+02	.18381+03	.23983+04
	.50000+03	.10567+02	.14833+02	.24544+03	.92833+02	.25863+02	.75231+00	.42208+01	.80000+02	.11186+04
	.61725+00		.80702+02	.25228+01	.84146+01	.84146+01	.42208+01	.43474+01	.20000+02	.10618+04
	.70000+02			.74017+00				.22511+03	.21500+02	
.3600+02	.36000+02	.74780-01	.11475+02	.16666+04	.88819+02	.21542+03	.21612+01	.23186+02	.18531+03	.24854+04
	.50000+03	.11337+02	.15409+02	.24617+03	.93647+02	.26193+02	.74569+00	.43474+01	.80000+02	.12011+04
	.60687+00		.81503+02	.24672+01	.82245+01	.82245+01	.43474+01	.44778+01	.20000+02	.11427+04

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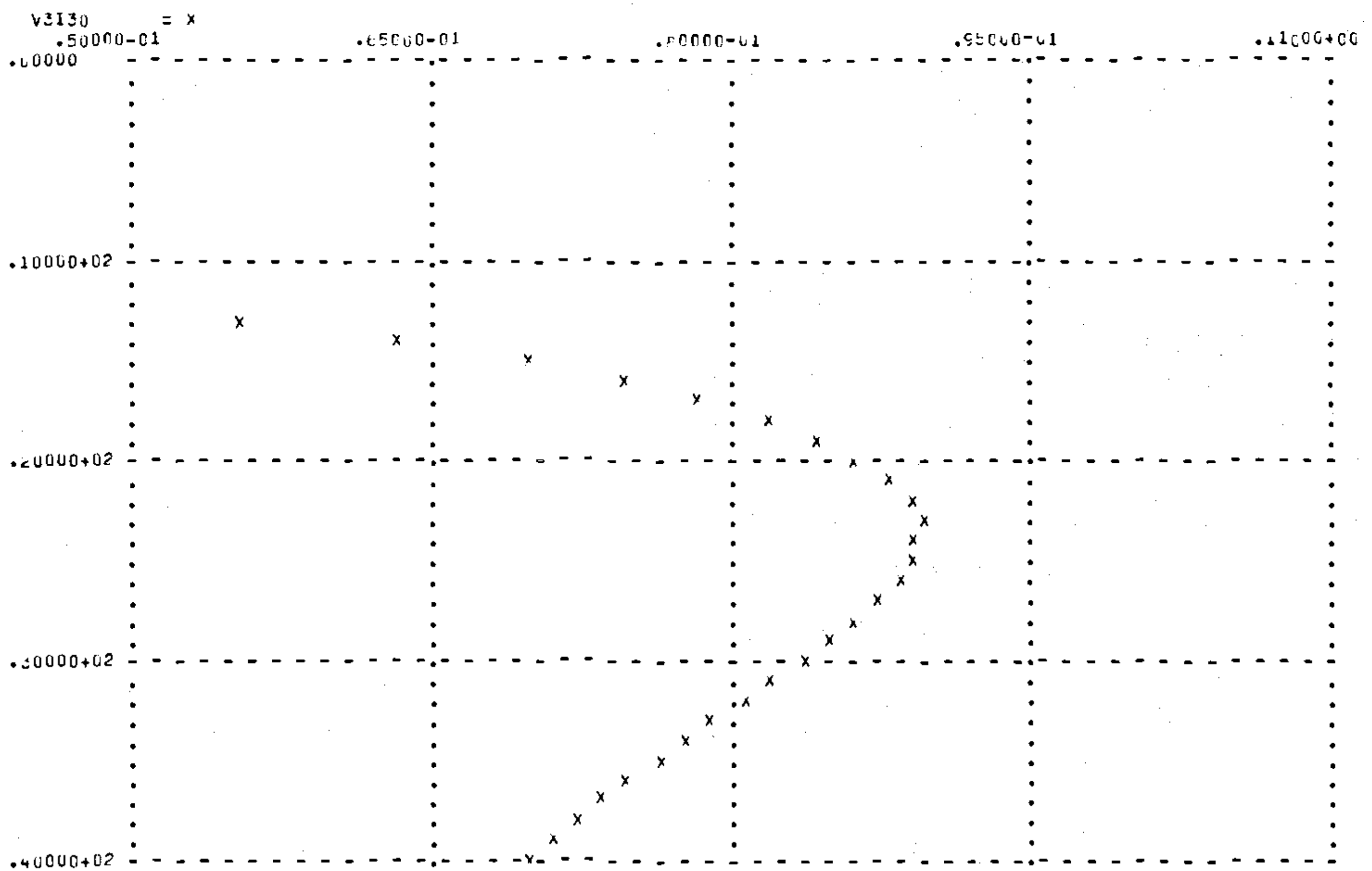
TIME	AGE TPA SURF SITEI	V3I30 CWC14	DBH DBHT HGH	V3IWT BASAS V3I61 BASA4	V3I60 V3I5 CCF80	CCF68 CCF90 CCF80	V3I16 V3I62 EE	E2 E3 E4 E1	INV ILV SFC1 SFPC	V3I24 CWC12 CWC11
	.70000+02			.73801+00				.23186+03	.21500+02	
.3700+02	.37000+02	.73451-01	.11558+02	.17077+04	.89210+02	.21357+03	.24069+01	.23882+02	.18677+03	.25719+04
	.50000+03	.12180+02	.16008+02	.24673+03	.94341+02	.26529+02	.74929+00	.44778+01	.80000+02	.12891+04
	.59665+00		.82269+02	.24111+01	.80506+01	.80506+01	.44778+01	.46122+01	.20000+02	.12289+04
	.70000+02			.73674+00				.23882+03	.21500+02	
.3800+02	.38000+02	.72170-01	.11637+02	.17479+04	.89514+02	.21209+03	.24574+01	.24598+02	.18821+03	.26587+04
	.50000+03	.13094+02	.16630+02	.24718+03	.94935+02	.26888+02	.74416+00	.46122+01	.80000+02	.13829+04
	.58660+00		.83000+02	.23556+01	.78881+01	.78881+01	.46122+01	.47505+01	.20000+02	.13209+04
	.70000+02			.73610+00				.24598+03	.21500+02	
.3900+02	.39000+02	.70949-01	.11715+02	.17874+04	.89774+02	.21064+03	.24092+01	.25336+02	.18962+03	.27471+04
	.50000+03	.14075+02	.17275+02	.24753+03	.95445+02	.27241+02	.74915+00	.47505+01	.80000+02	.14827+04
	.57671+00		.83701+02	.23019+01	.77327+01	.77327+01	.47505+01	.48931+01	.20000+02	.14189+04
	.70000+02			.73594+00				.25336+03	.21500+02	
.4000+02	.40000+02	.69770-01	.11791+02	.18263+04	.89944+02	.20933+03	.24037+01	.26096+02	.19100+03	.28357+04
	.50000+03	.15138+02	.17946+02	.24781+03	.95881+02	.27587+02	.74460+00	.48931+01	.80000+02	.15891+04
	.56699+00		.84371+02	.22486+01	.75879+01	.75879+01	.48931+01	.50398+01	.20000+02	.15233+04
	.70000+02			.73612+00				.26096+03	.21500+02	



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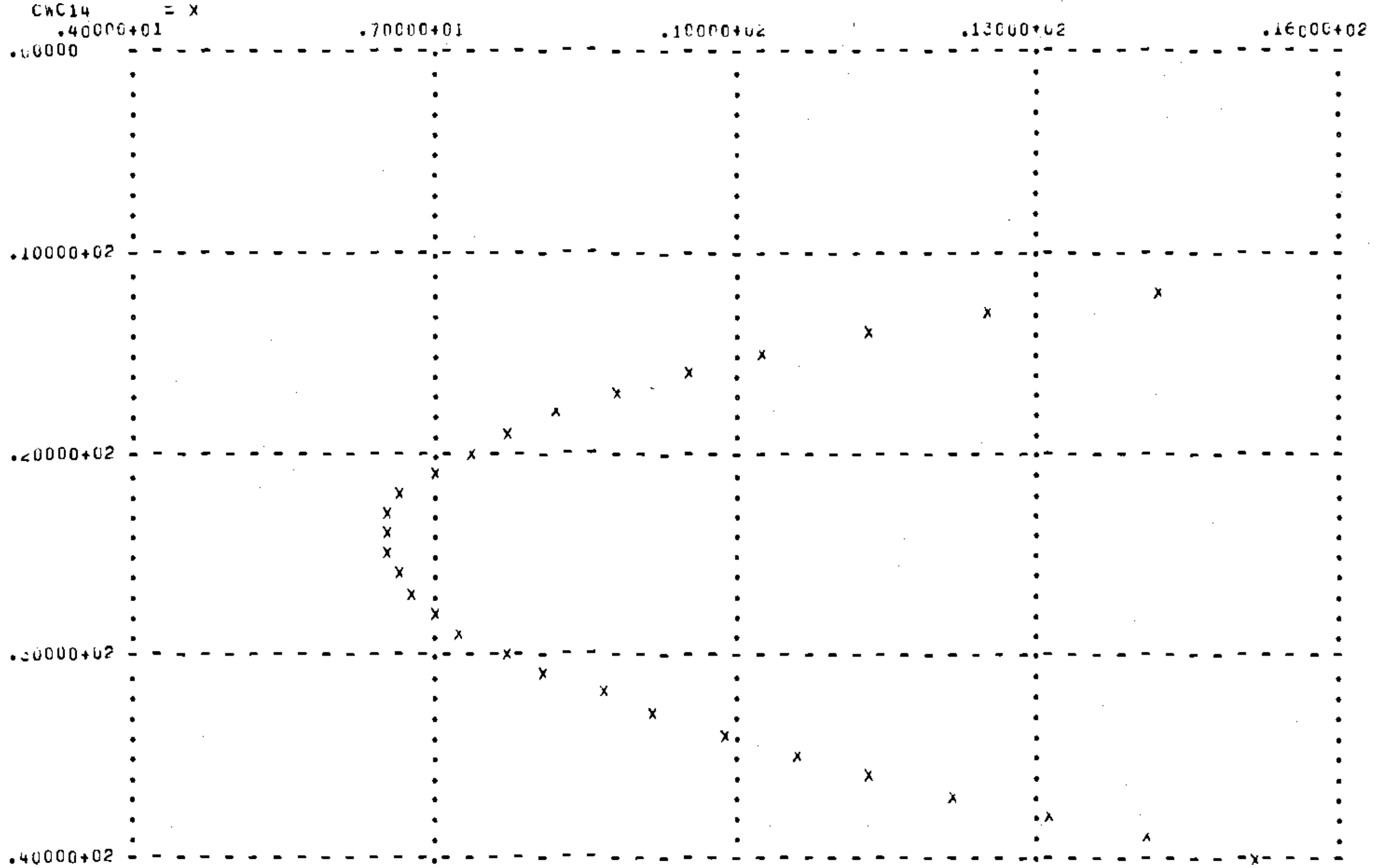

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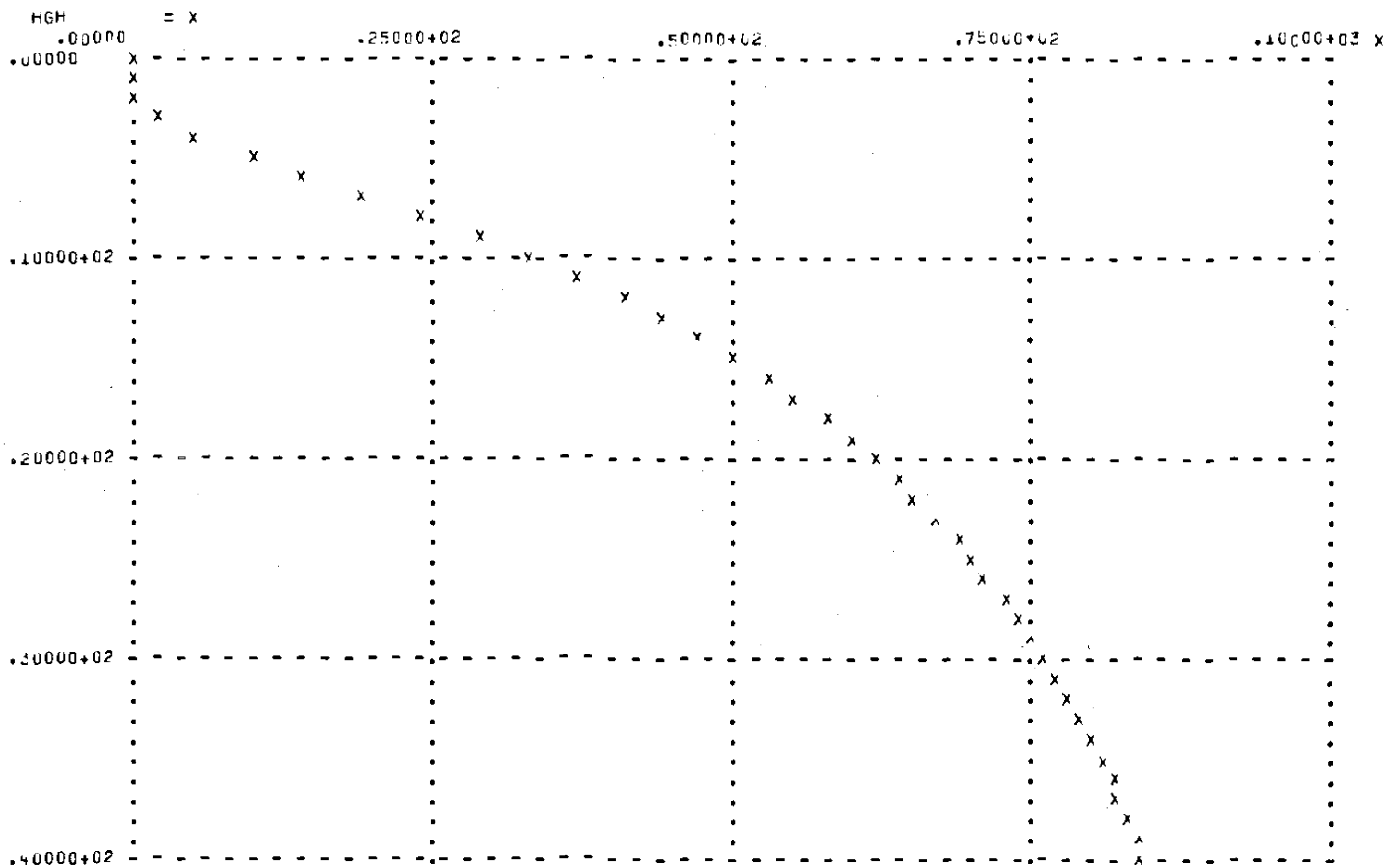

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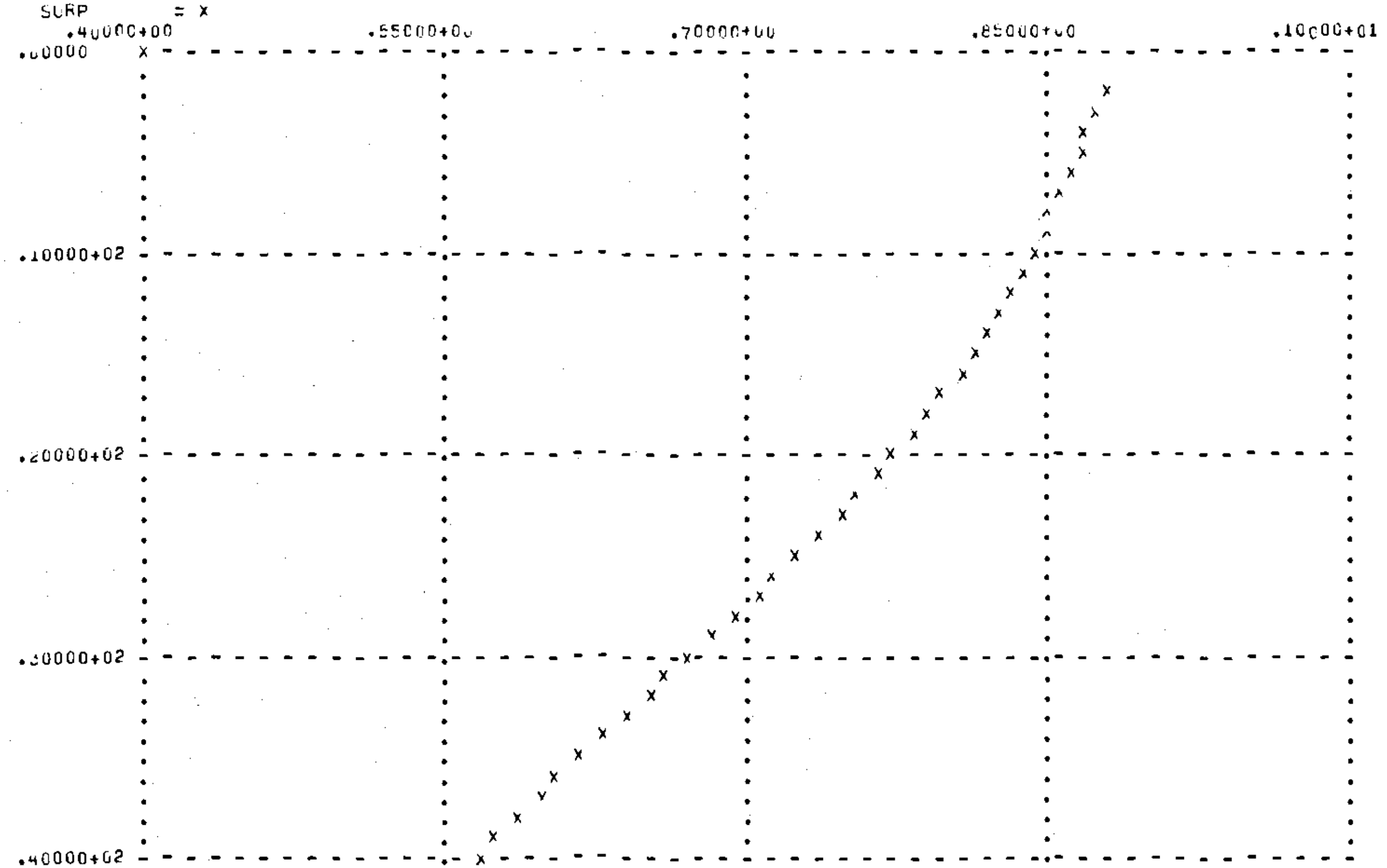

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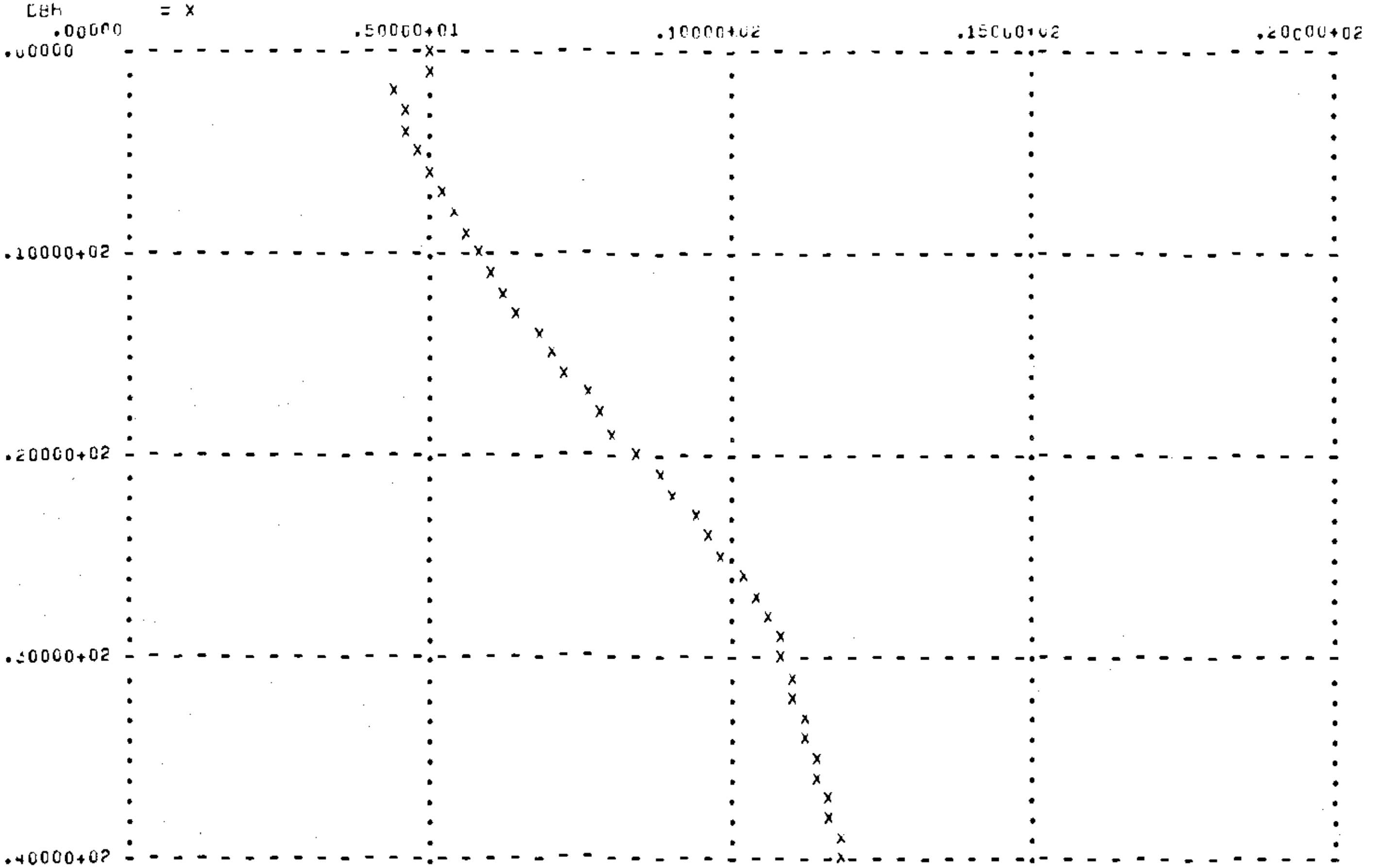

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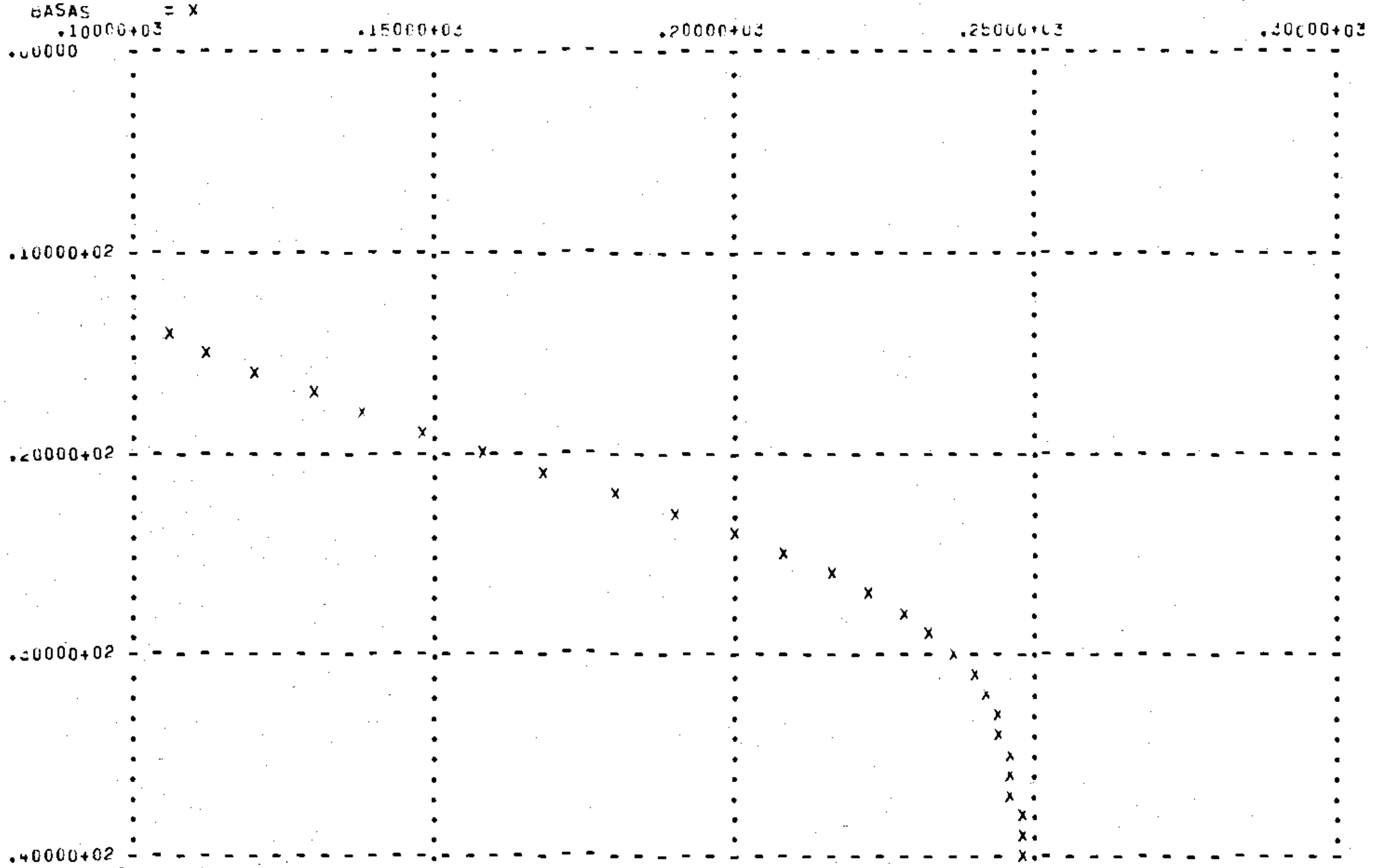

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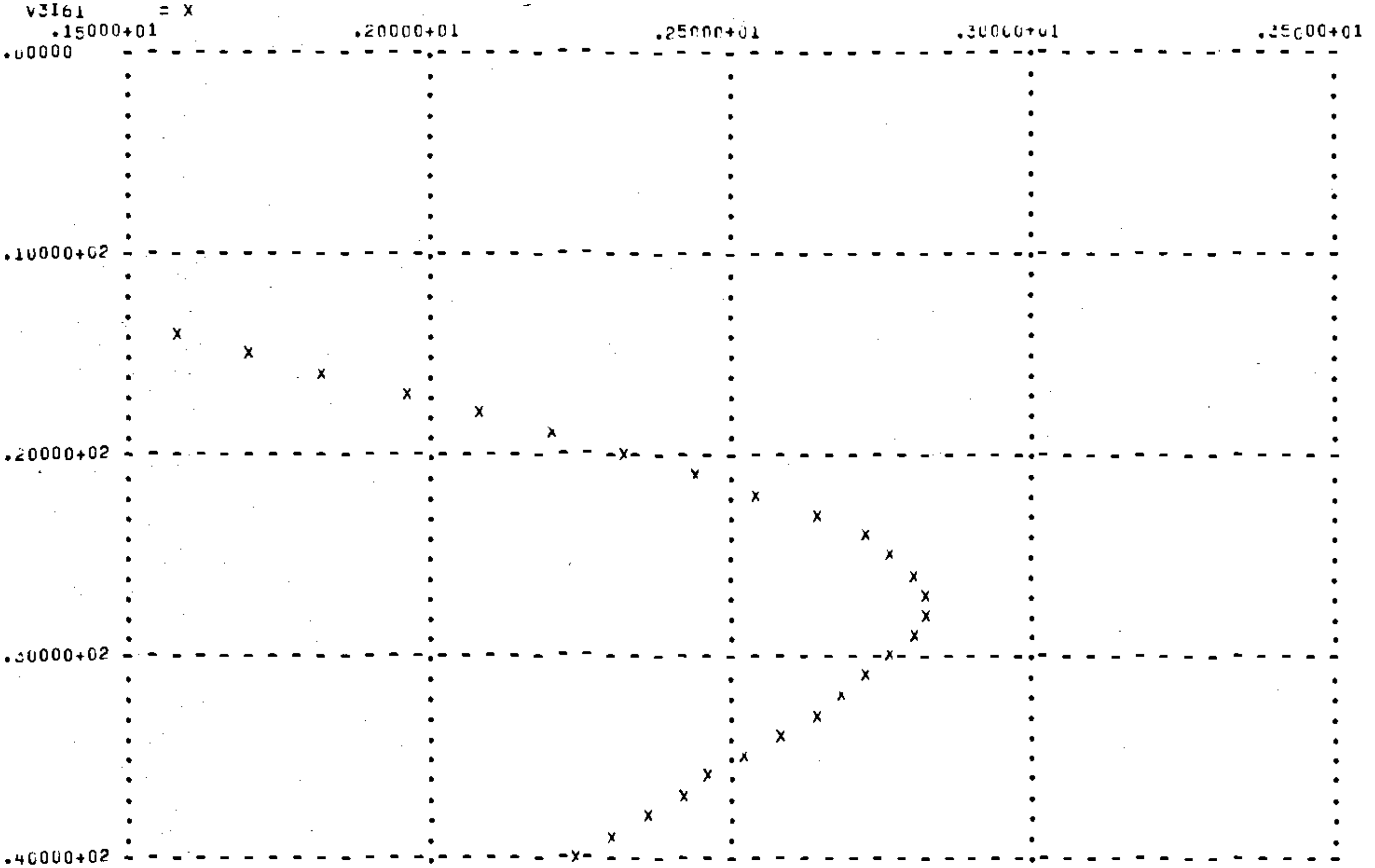
V3I61 = X



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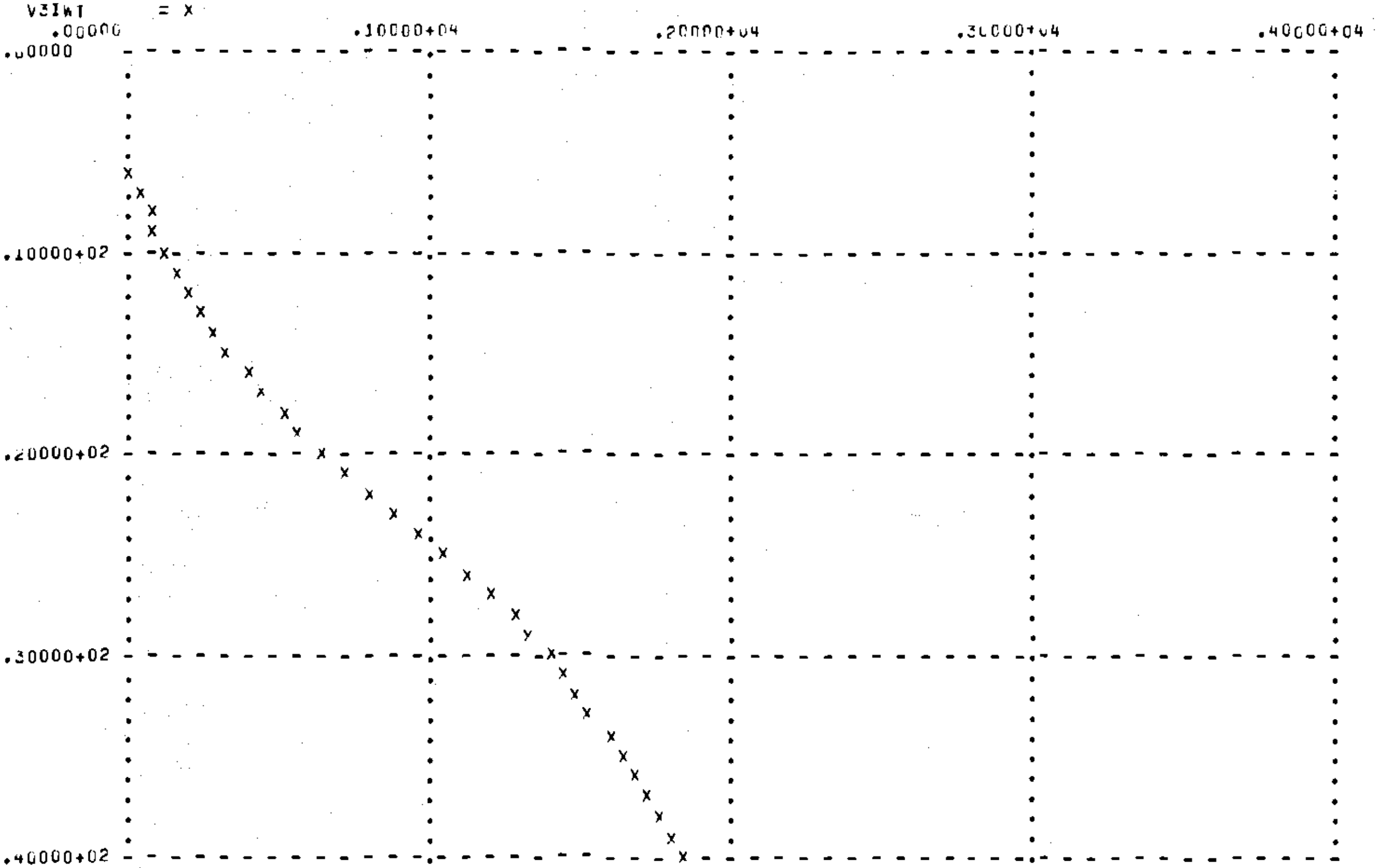
V3IWT = X



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APPENDIX IV

FOREST GROWTH MODEL RESULTS

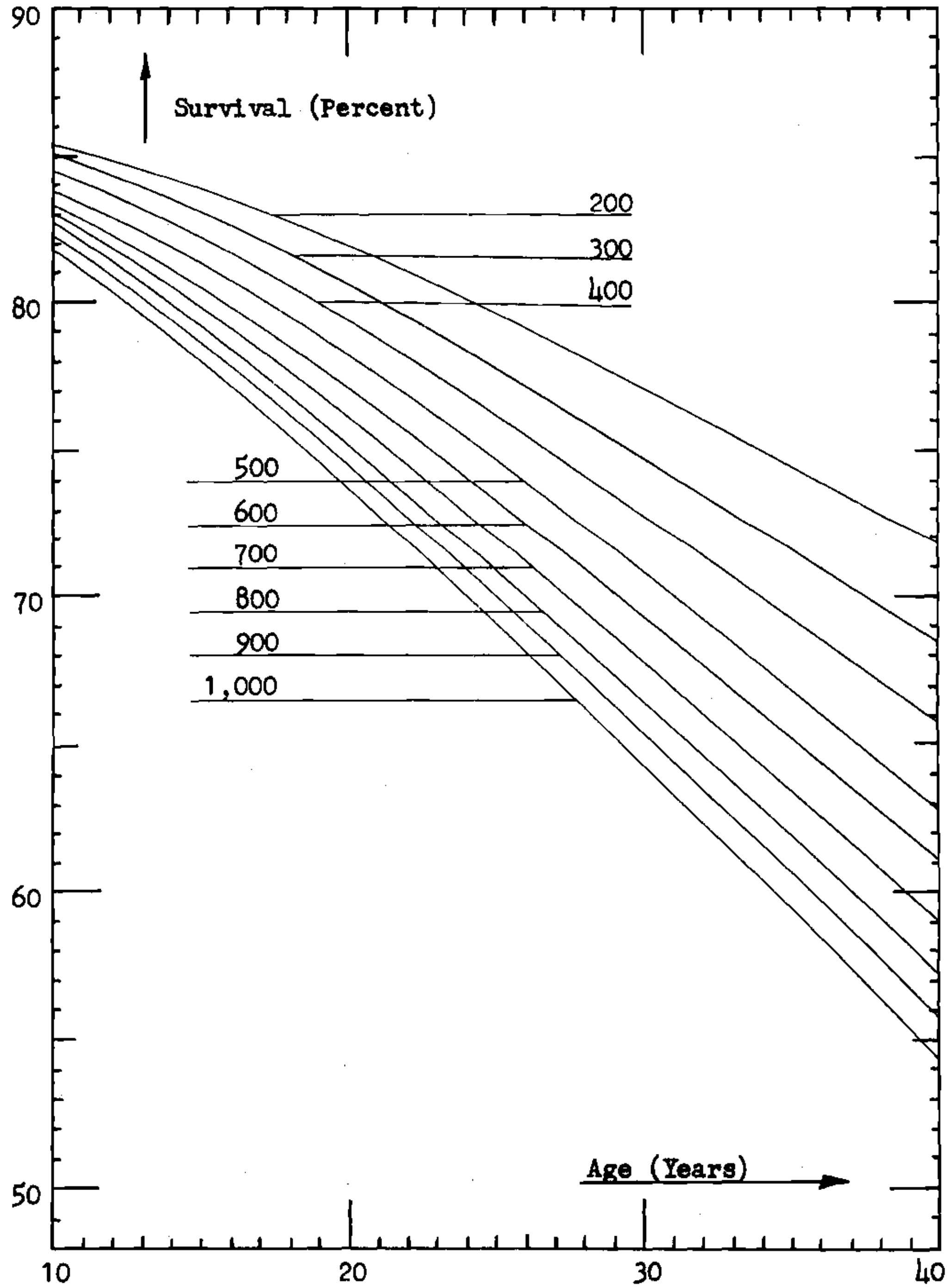

Figure 15. Survival versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 40

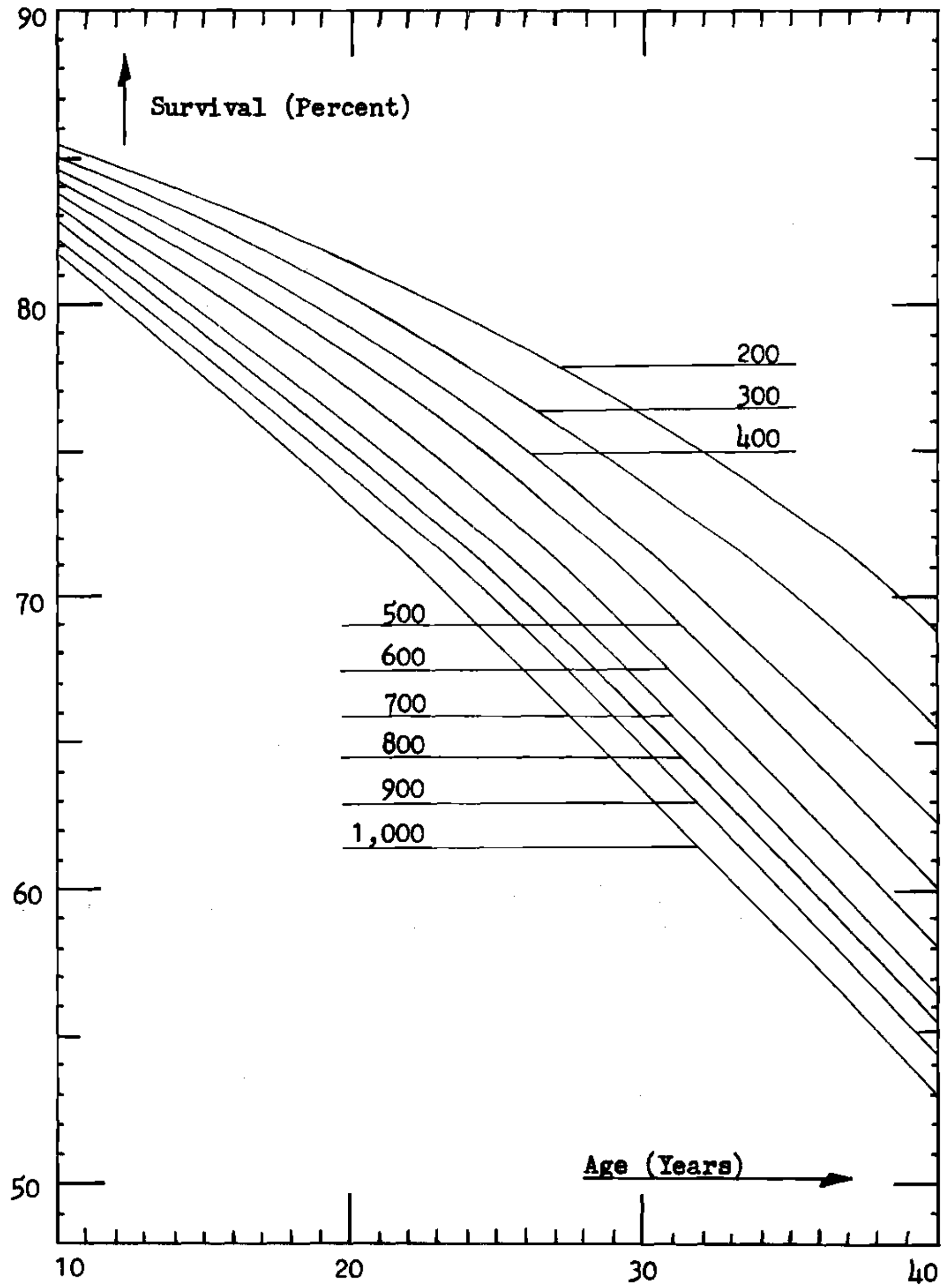

Figure 16. **Survival versus Age for Initial Planting Densities for 200 to 1,000 Trees per Acre on Land with Site Index 50**

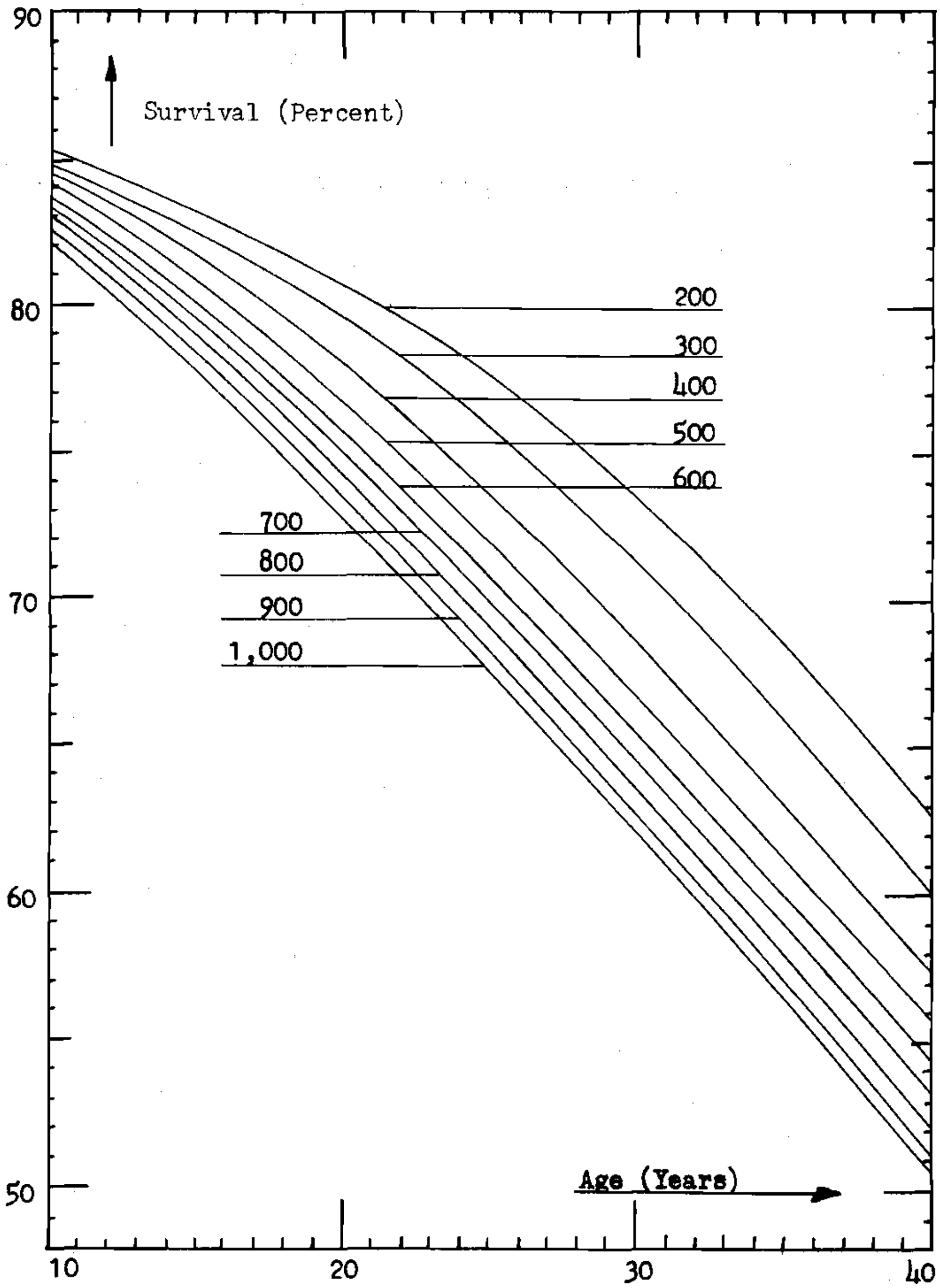

Figure 17. **Survival versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 70**

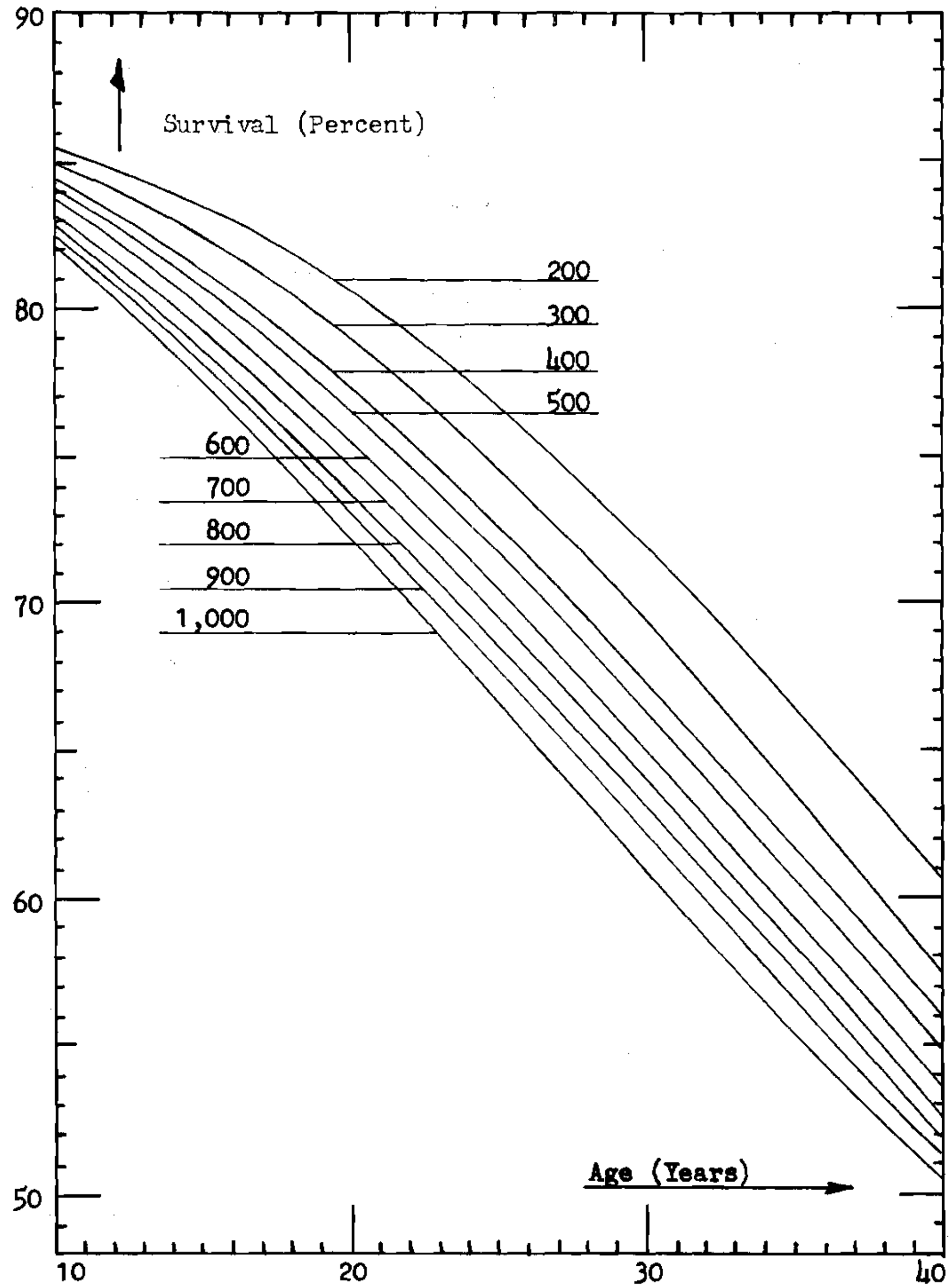

Figure 18. Survival versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 80

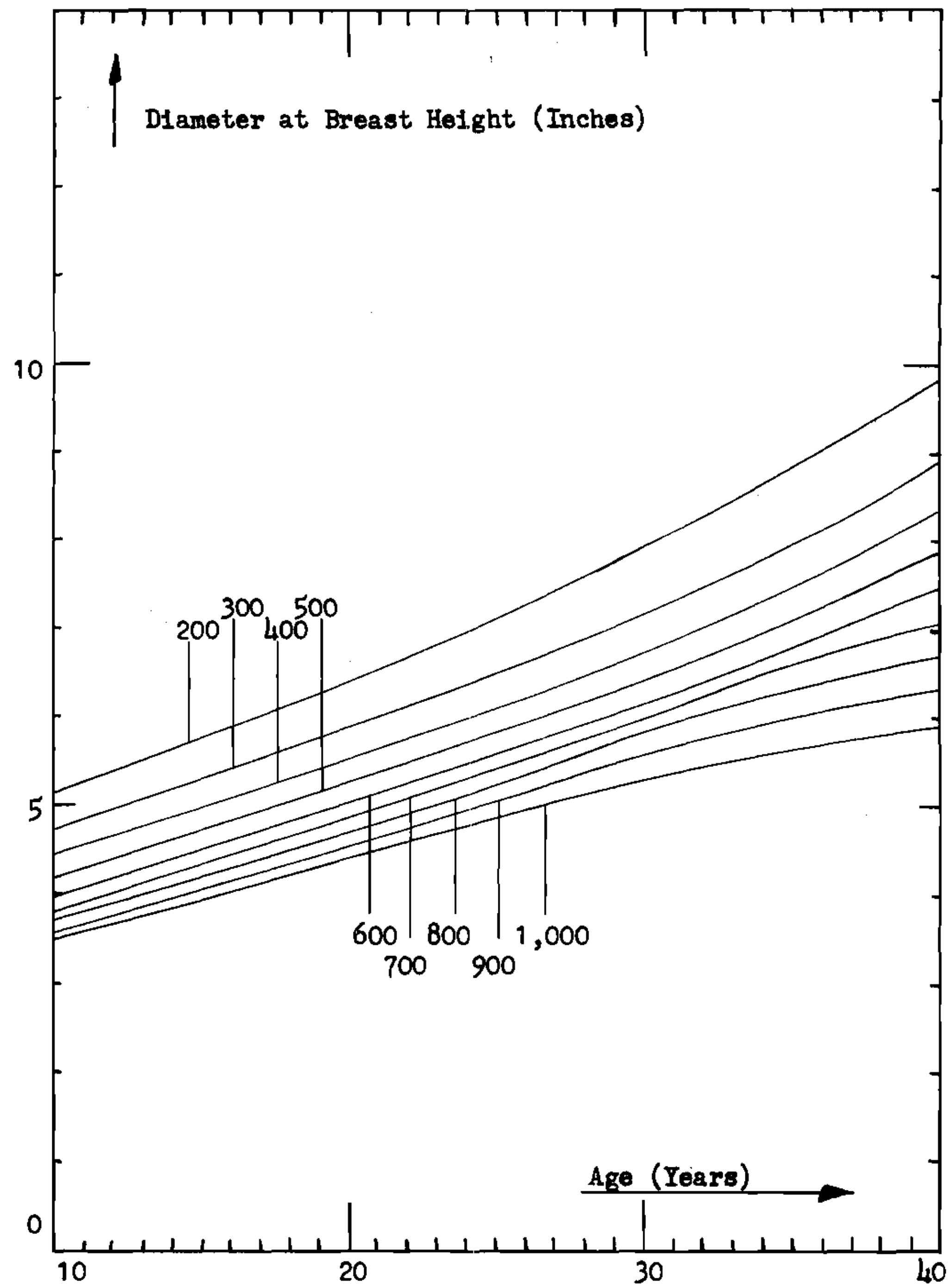

Figure 19. Diameter at Breast Height versus Age for Intial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 40

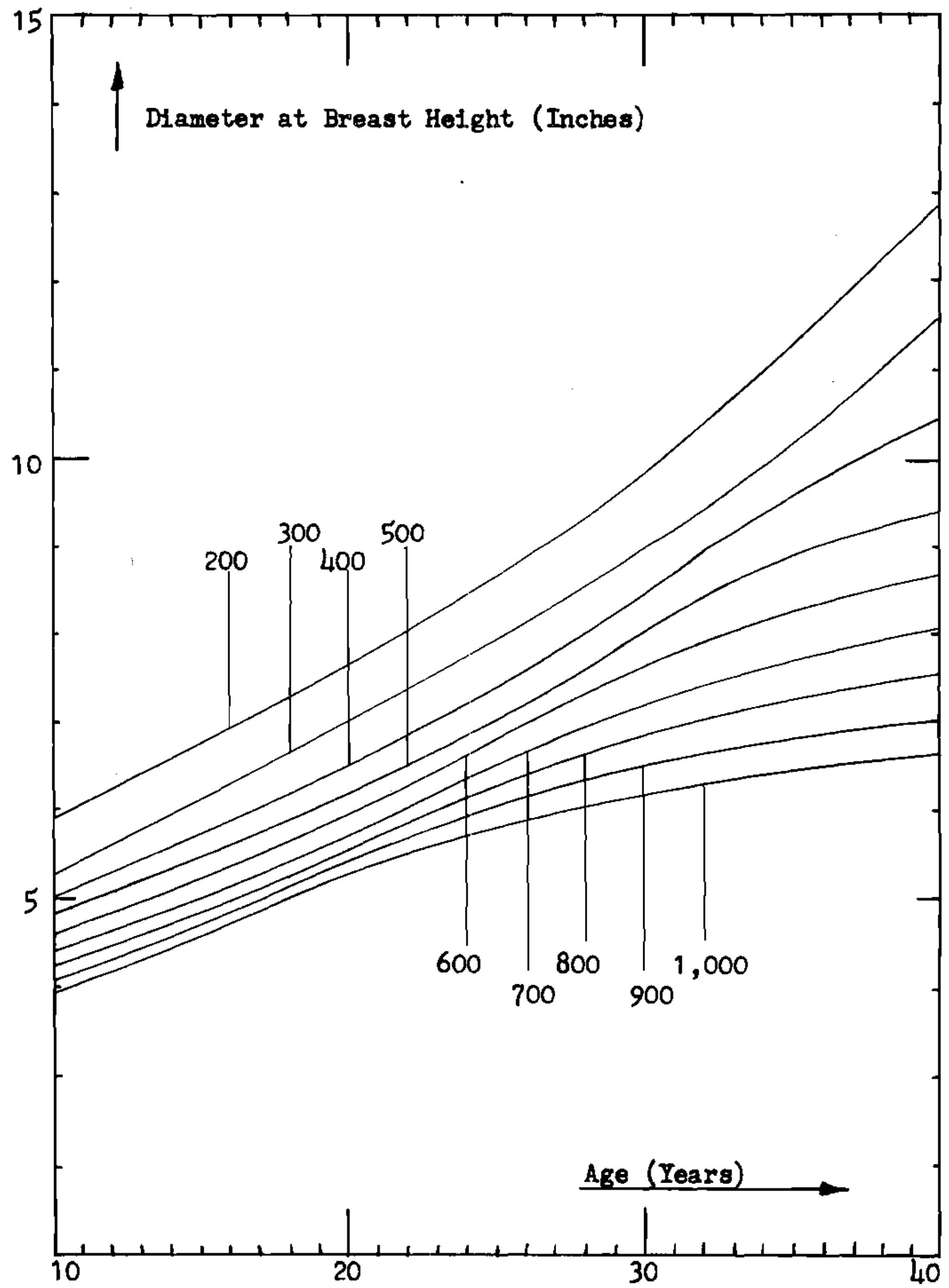

Figure 20. Diameter at Breast Height versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 50

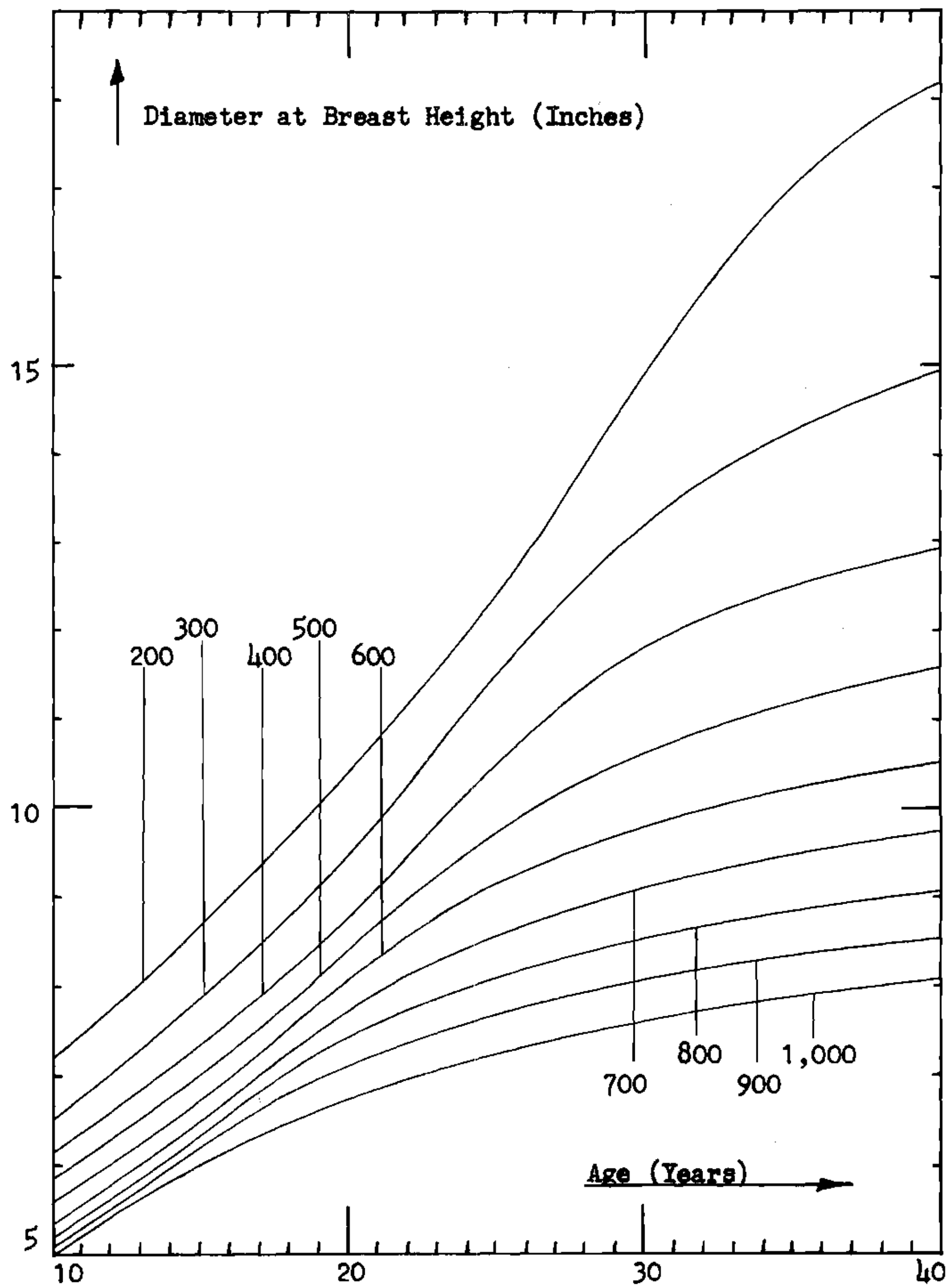

Figure 21. Diameter at Breast Height versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 70

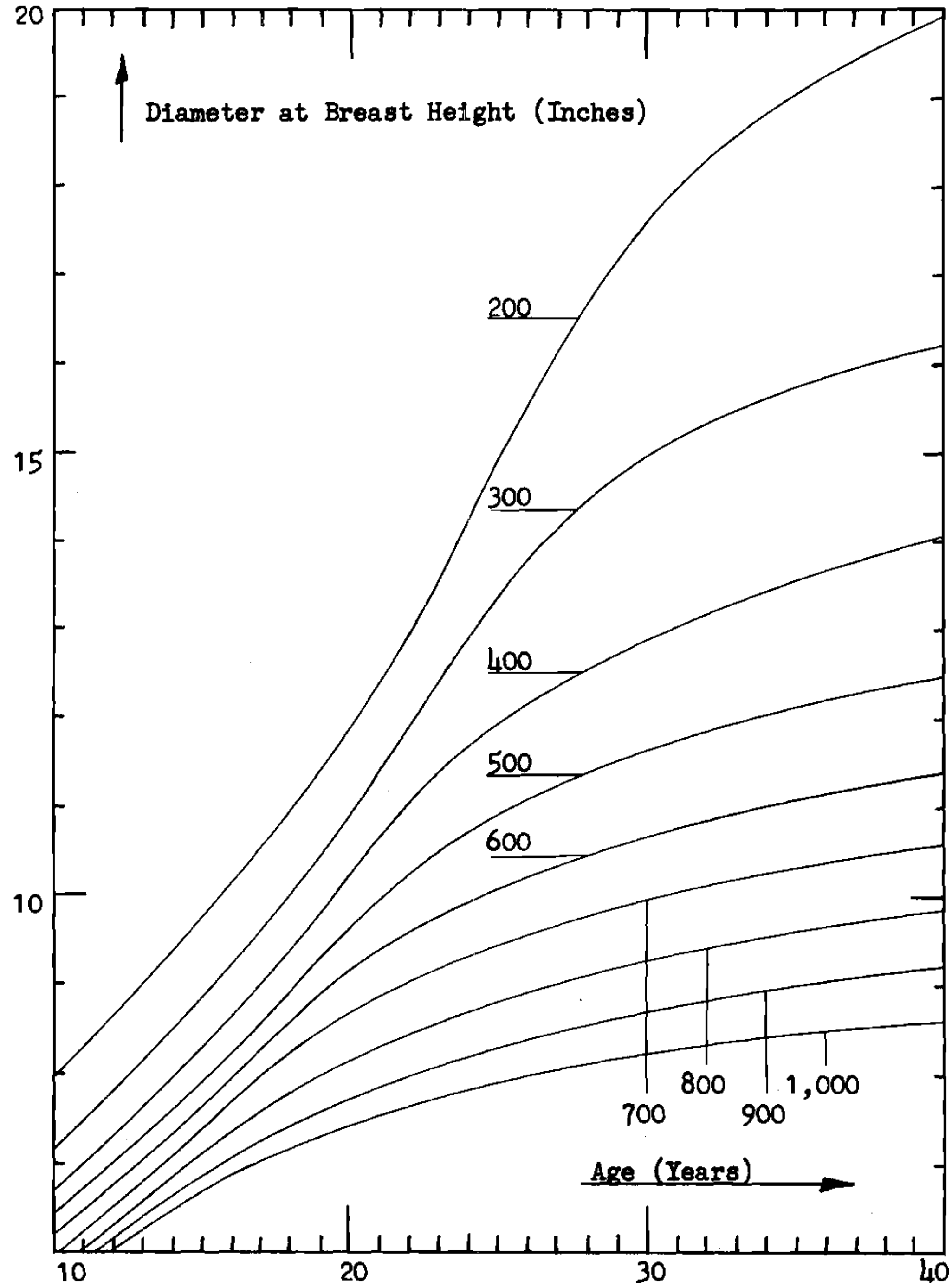

Figure 22. **Diameter at Breast Height versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 80**

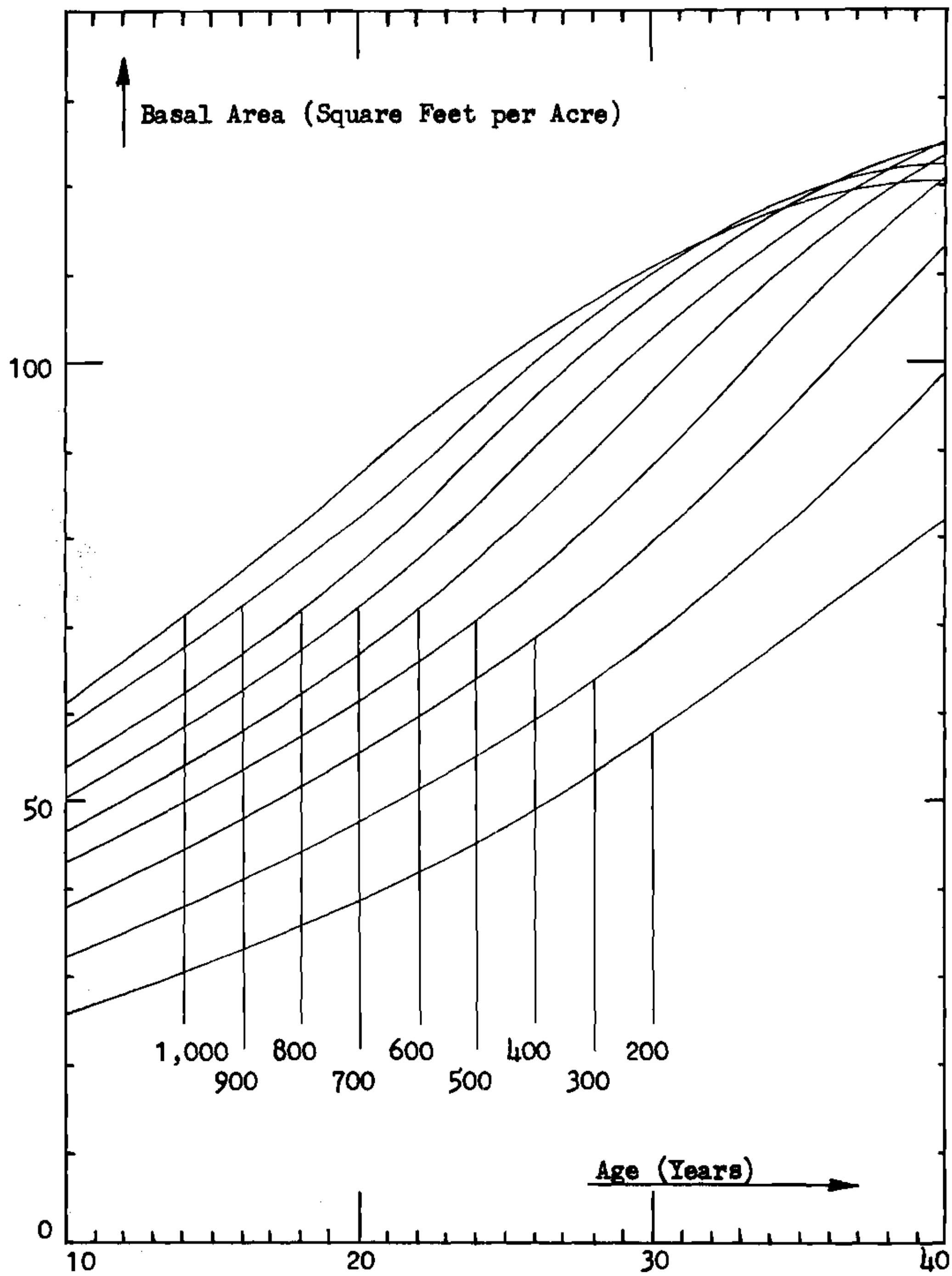

Figure 23. Basal Area versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 40

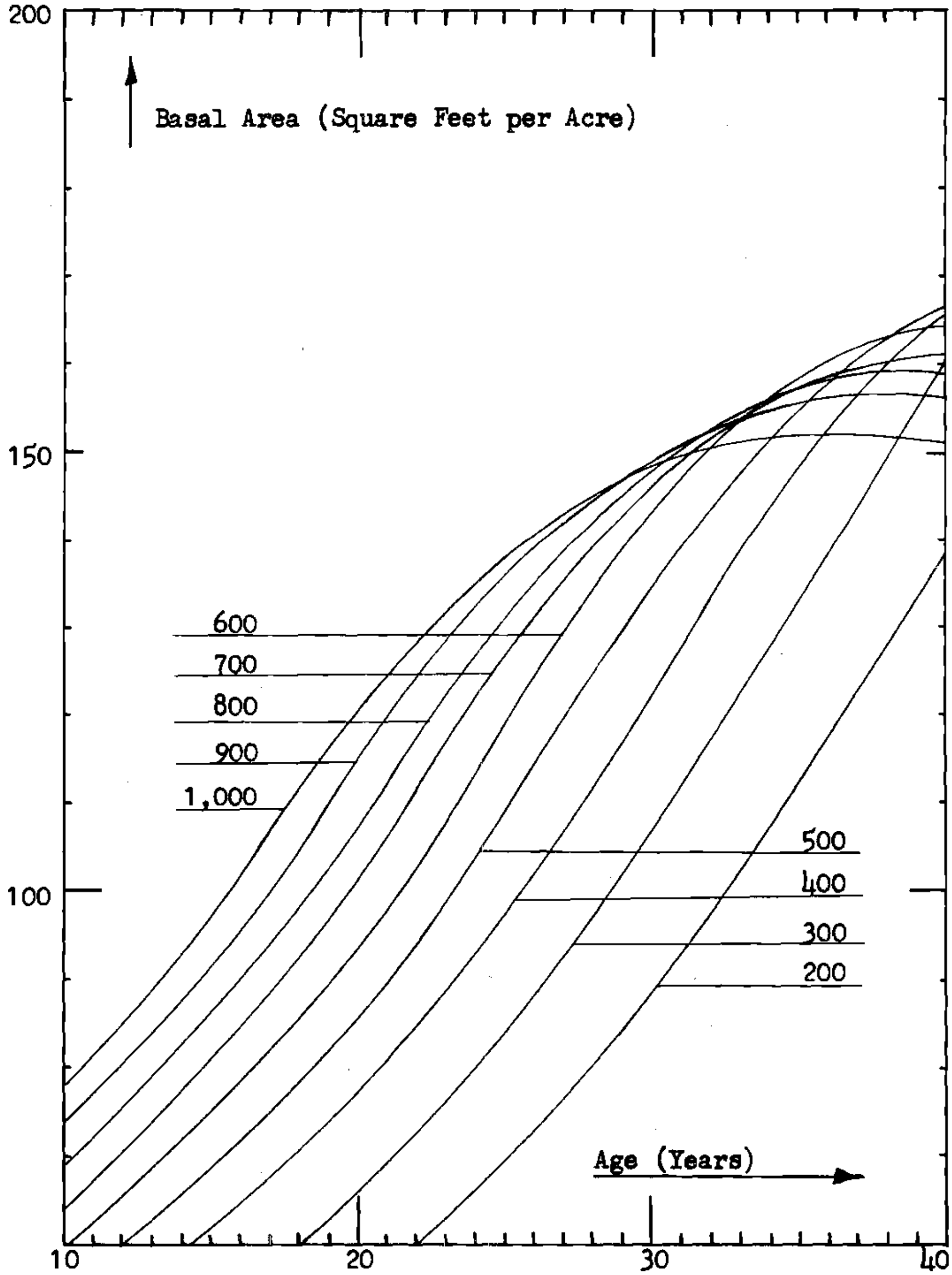

Figure 24. Basal Area versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 50

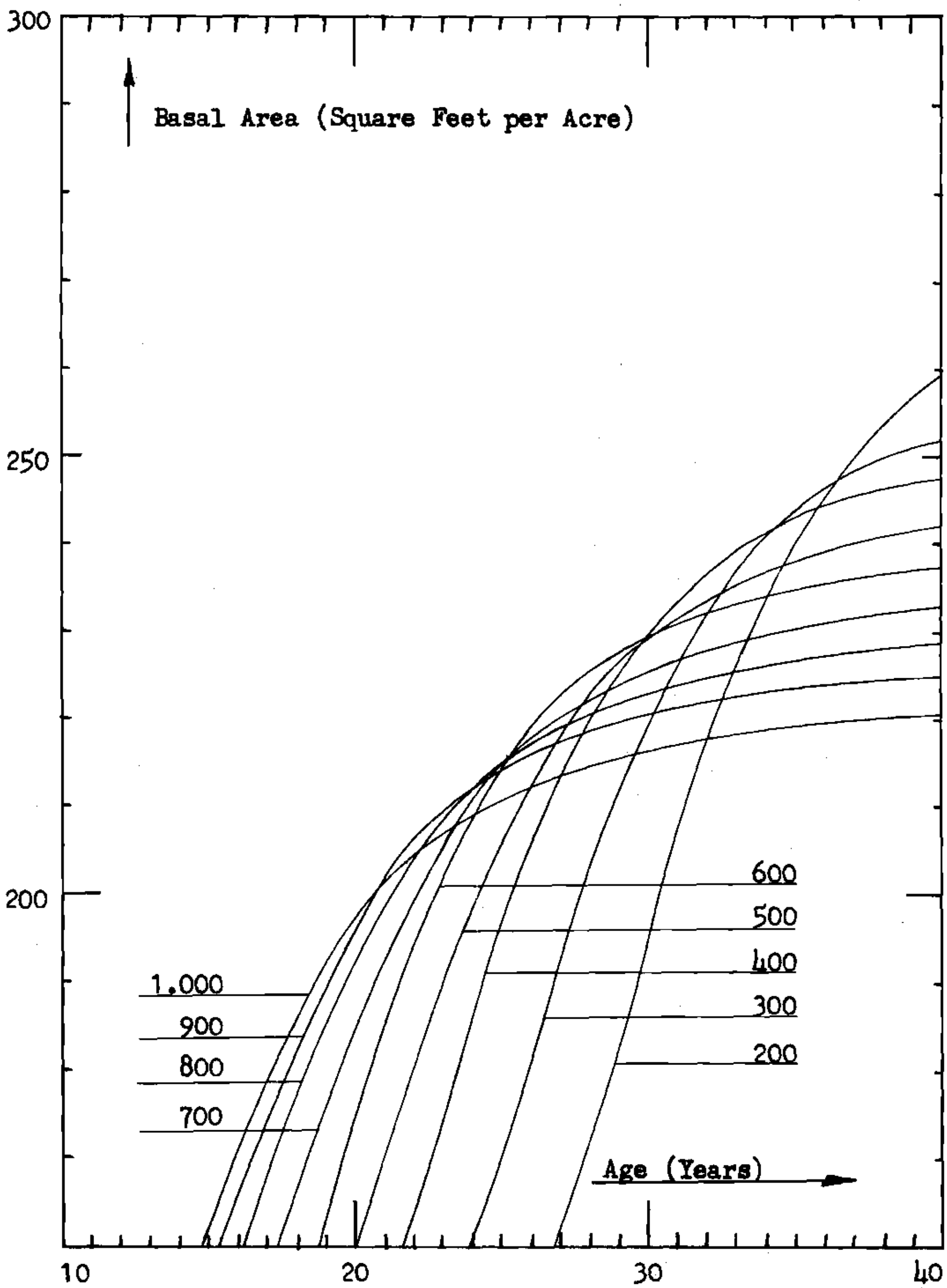

Figure 25. Basal Area versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 70

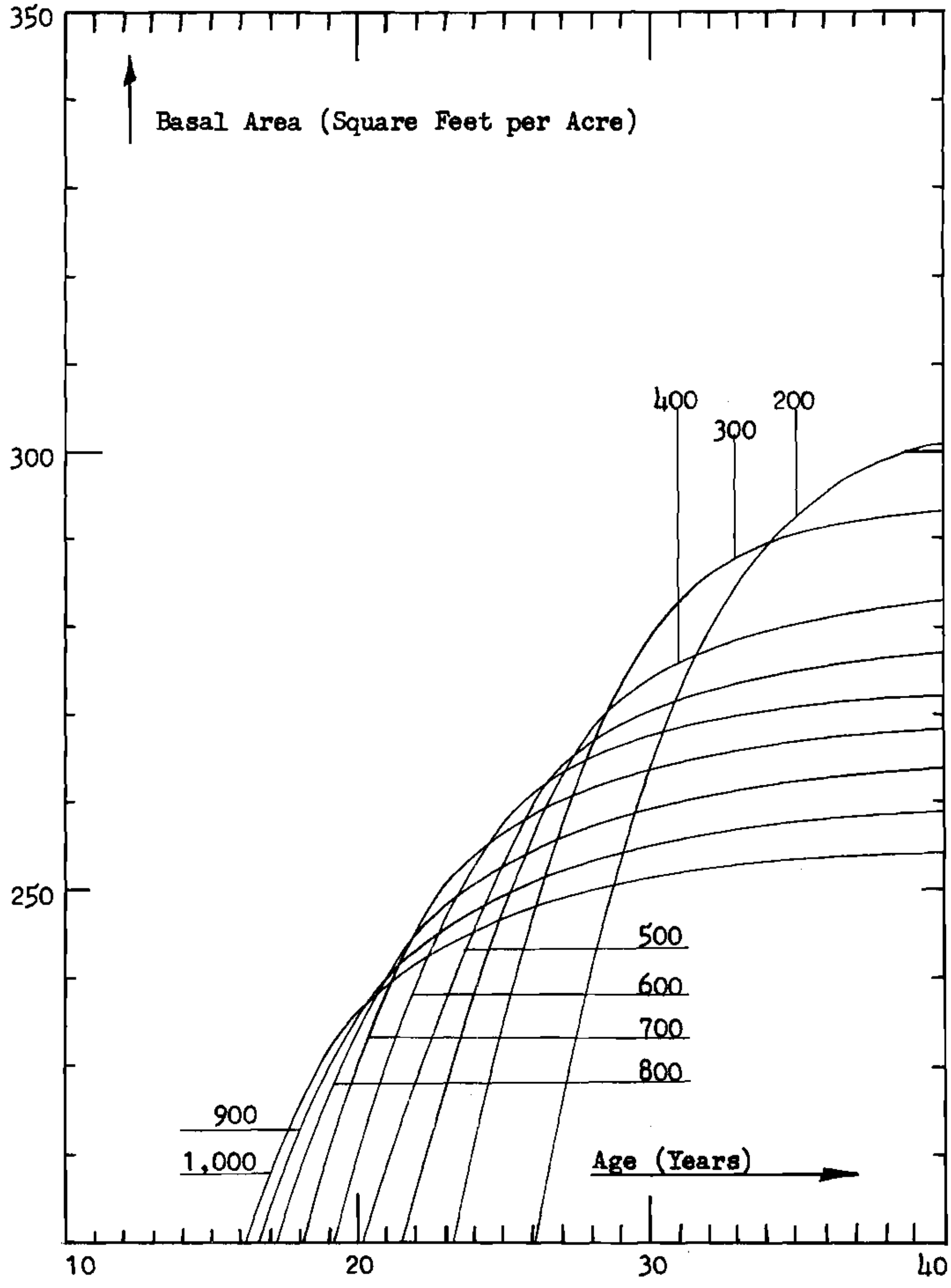

Figure 26. Basal Area versus Age for Intial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 80

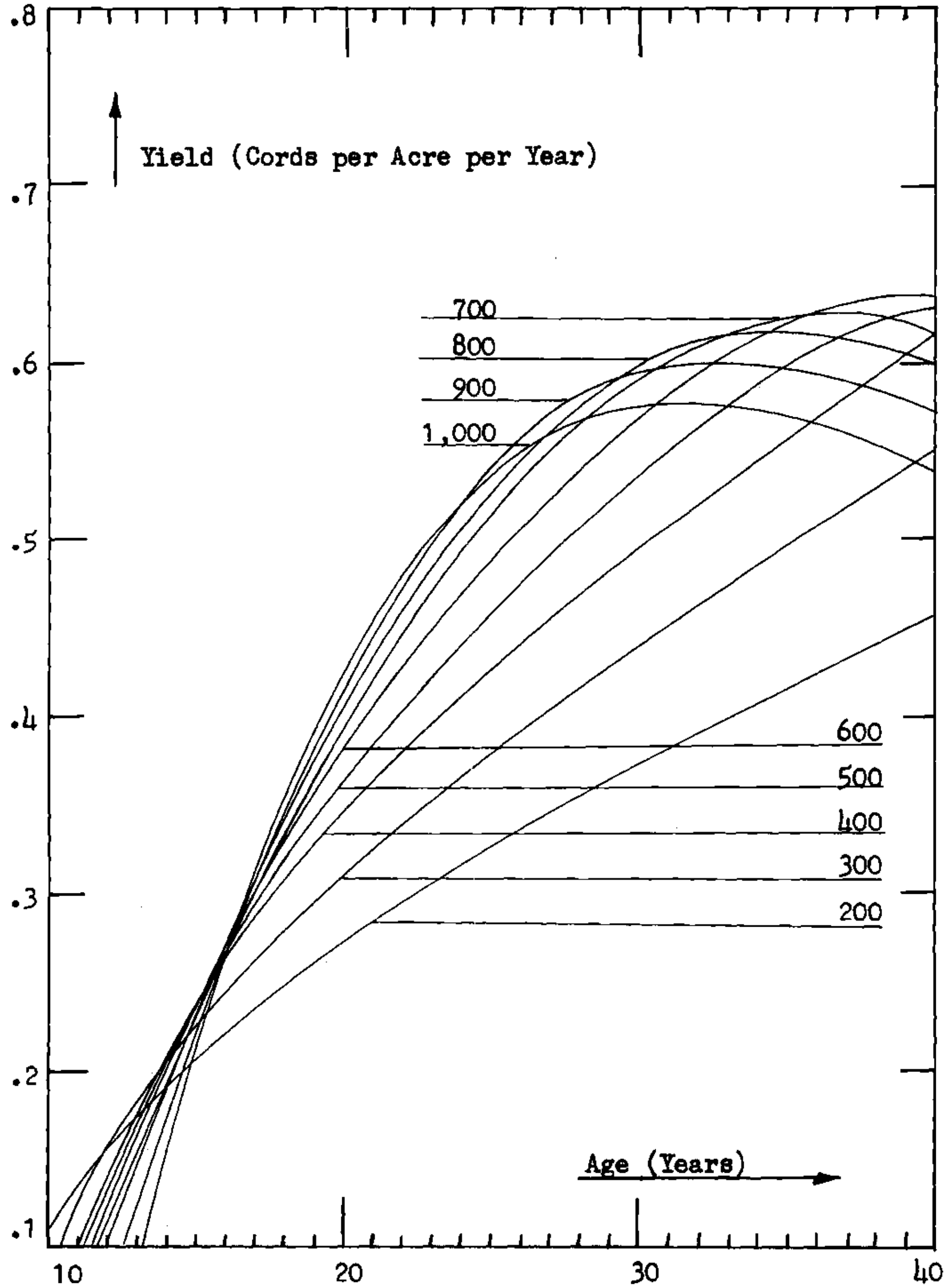

Figure 27. Harvestable Yield versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 40

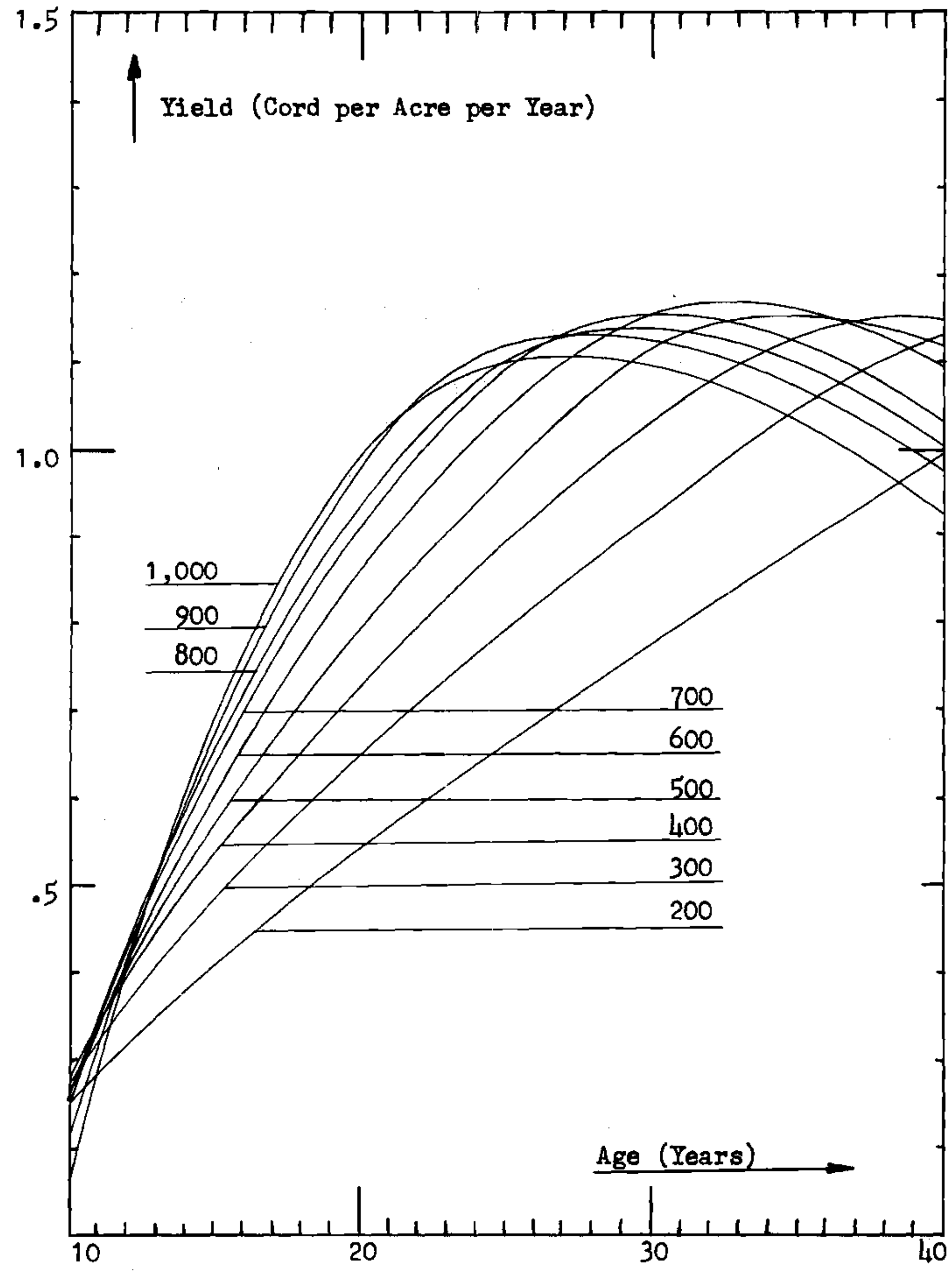

Figure 28. Harvestable Yield versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 50

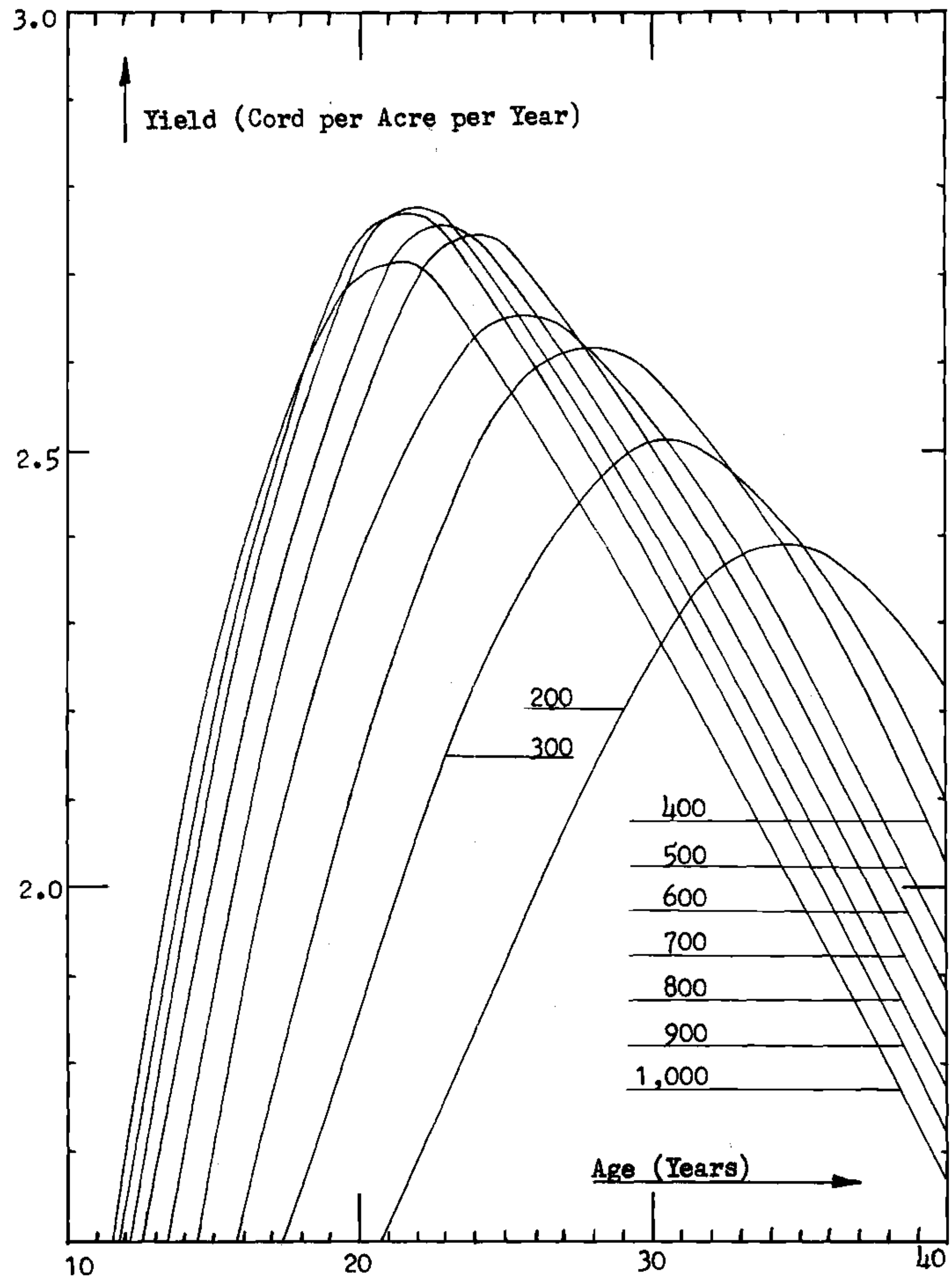

Figure 29. Harvestable Yield versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 70

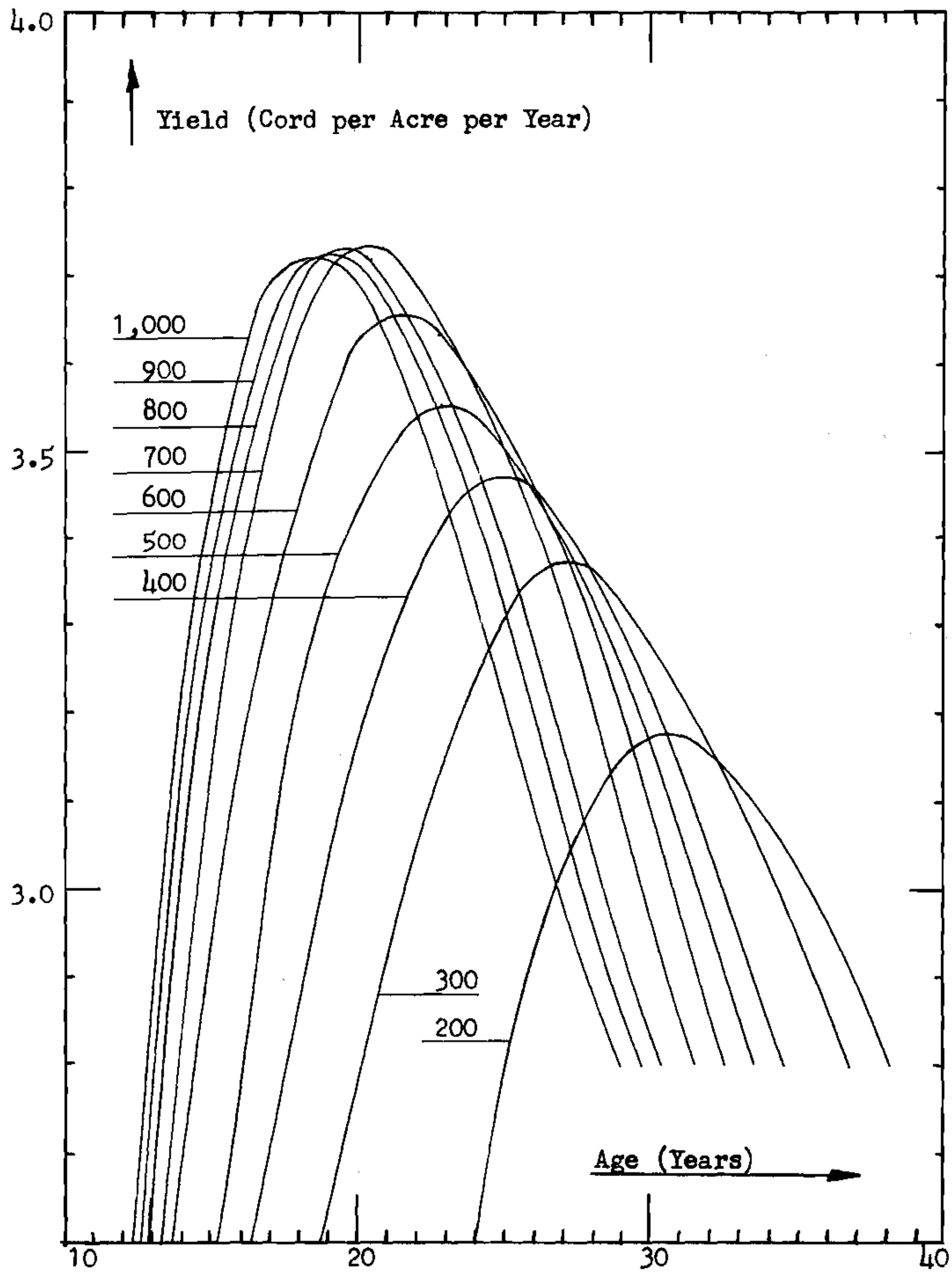

Figure 30. Harvestable Yield versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 80

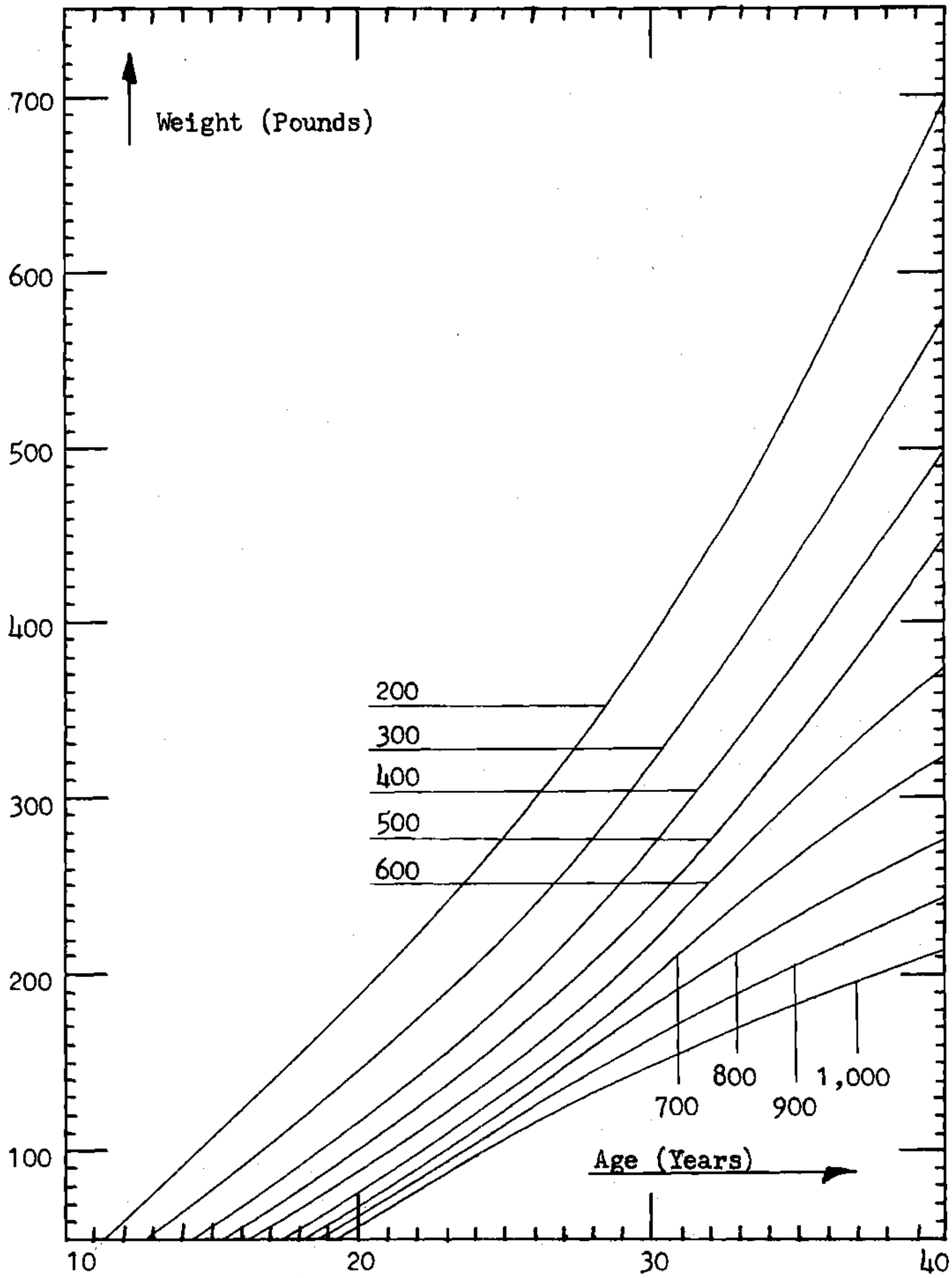

Figure 31. Merchantable Stem Weight versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 40

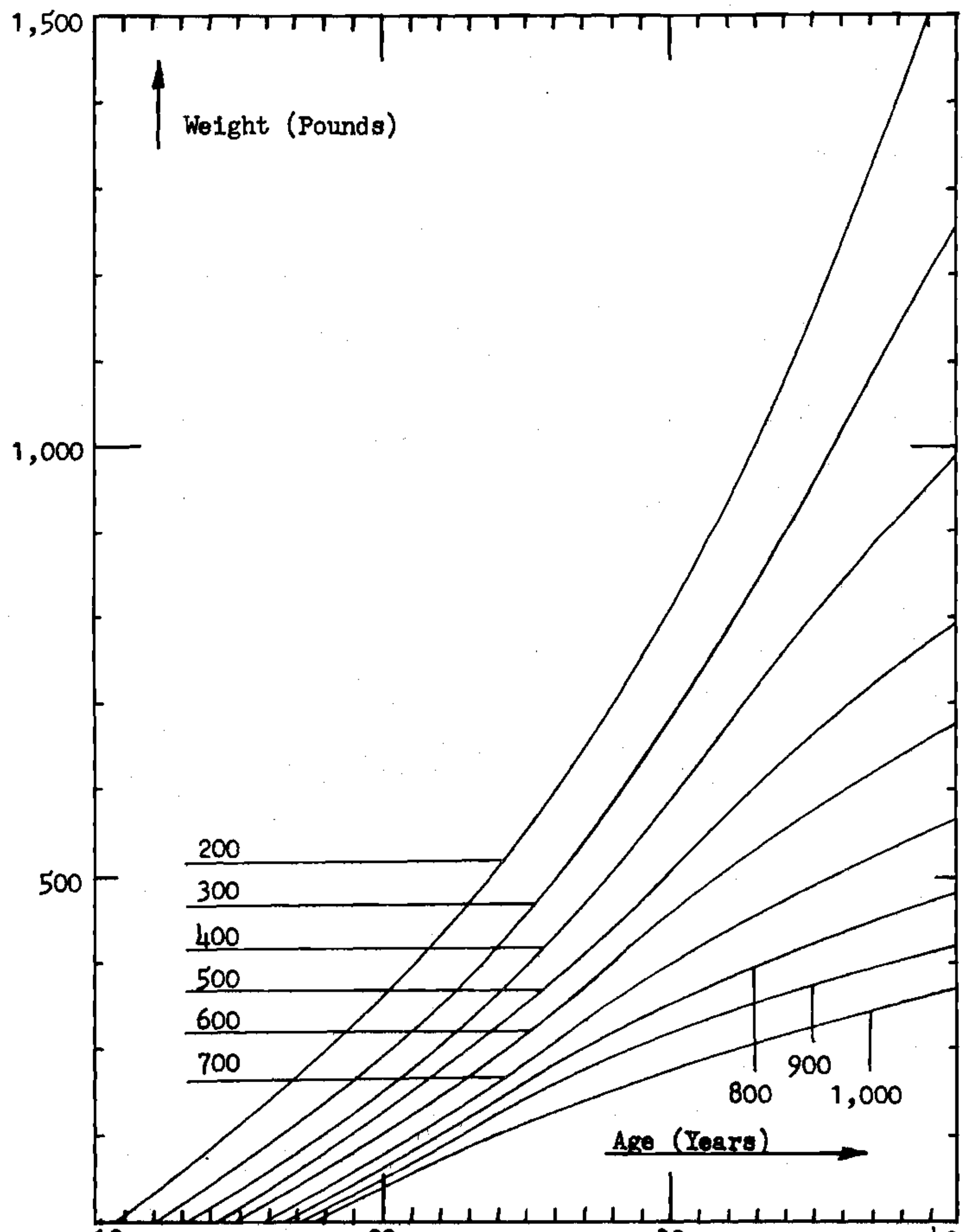

Figure 32. Merchantable Stem Weight versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 50

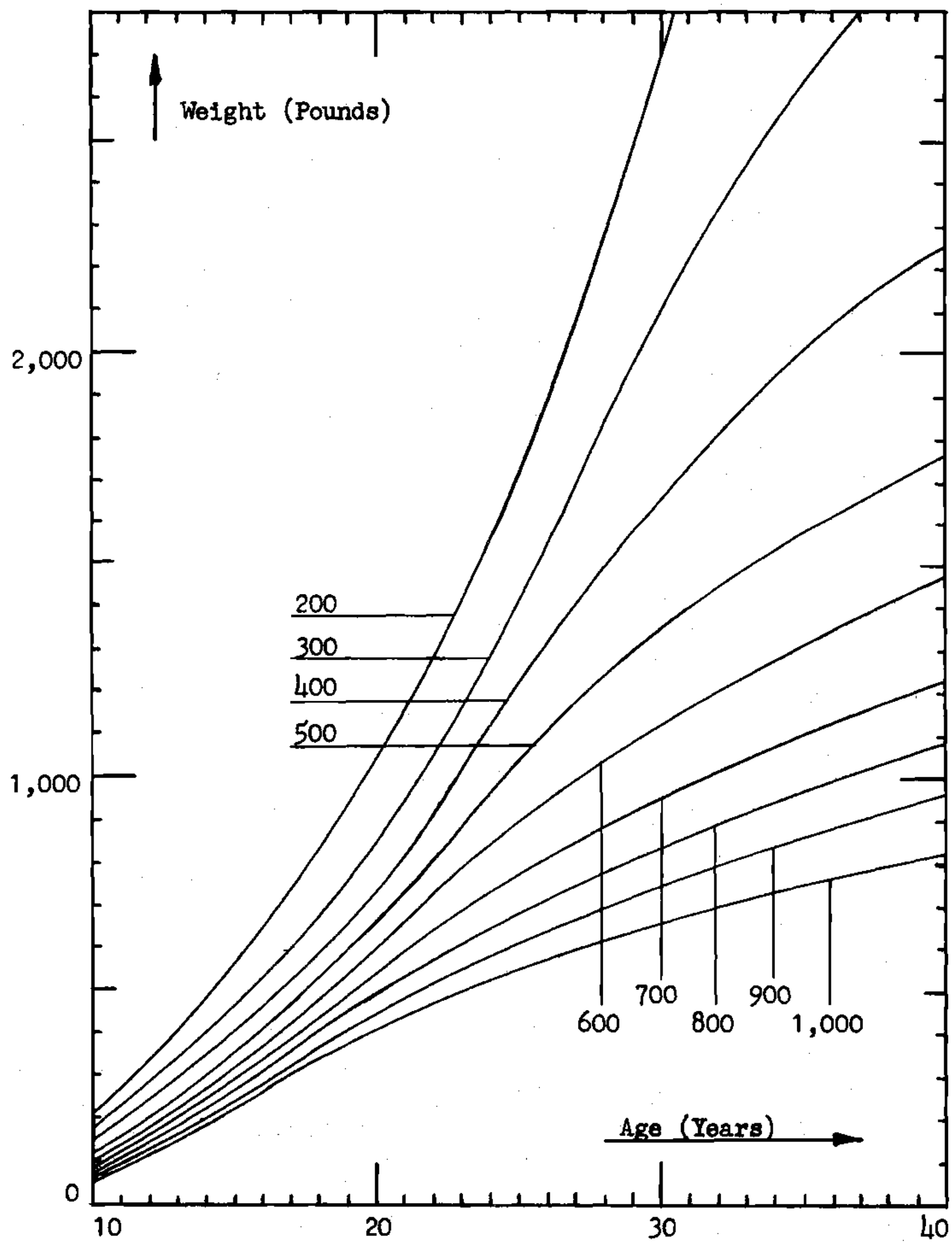

Figure 33. Merchantable Stem Weight versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 70

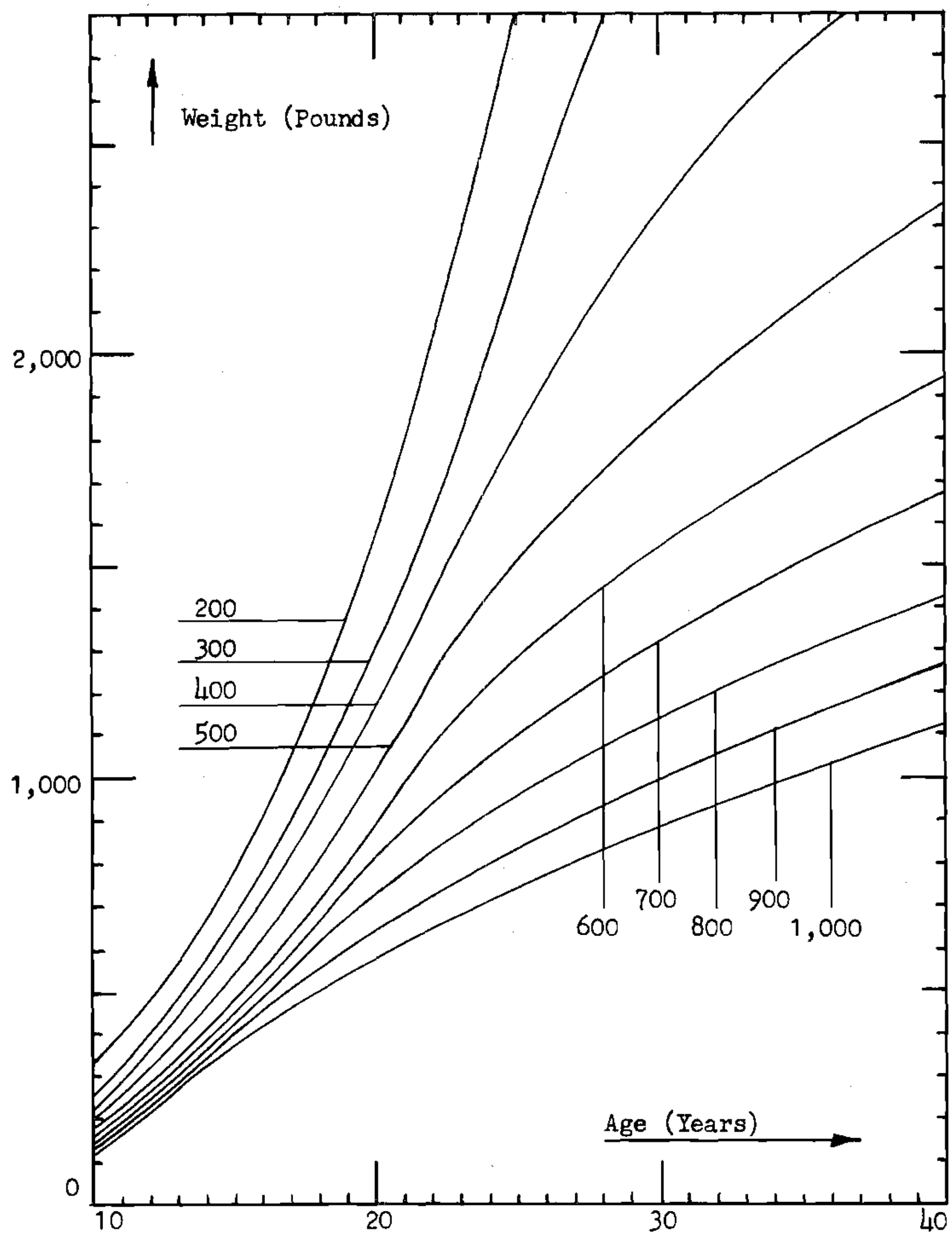

Figure 34. Merchantable Stem Weight versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 80

APPENDIX V

ECONOMIC MODEL RESULTS

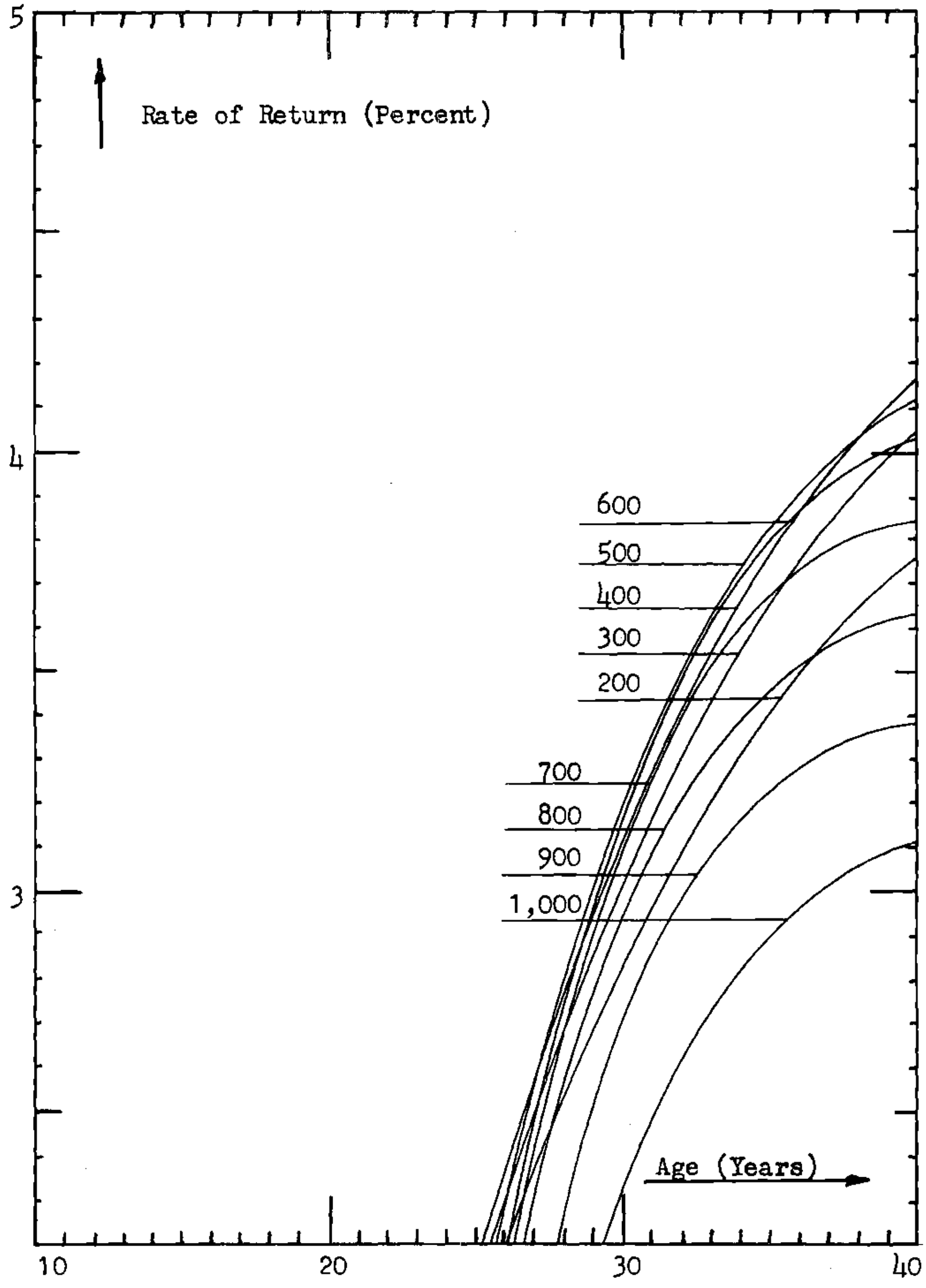

Figure 35. **Independent Landowner's Rate of Return on Forest Investment and Growing Cost (Site Clearance Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 40**

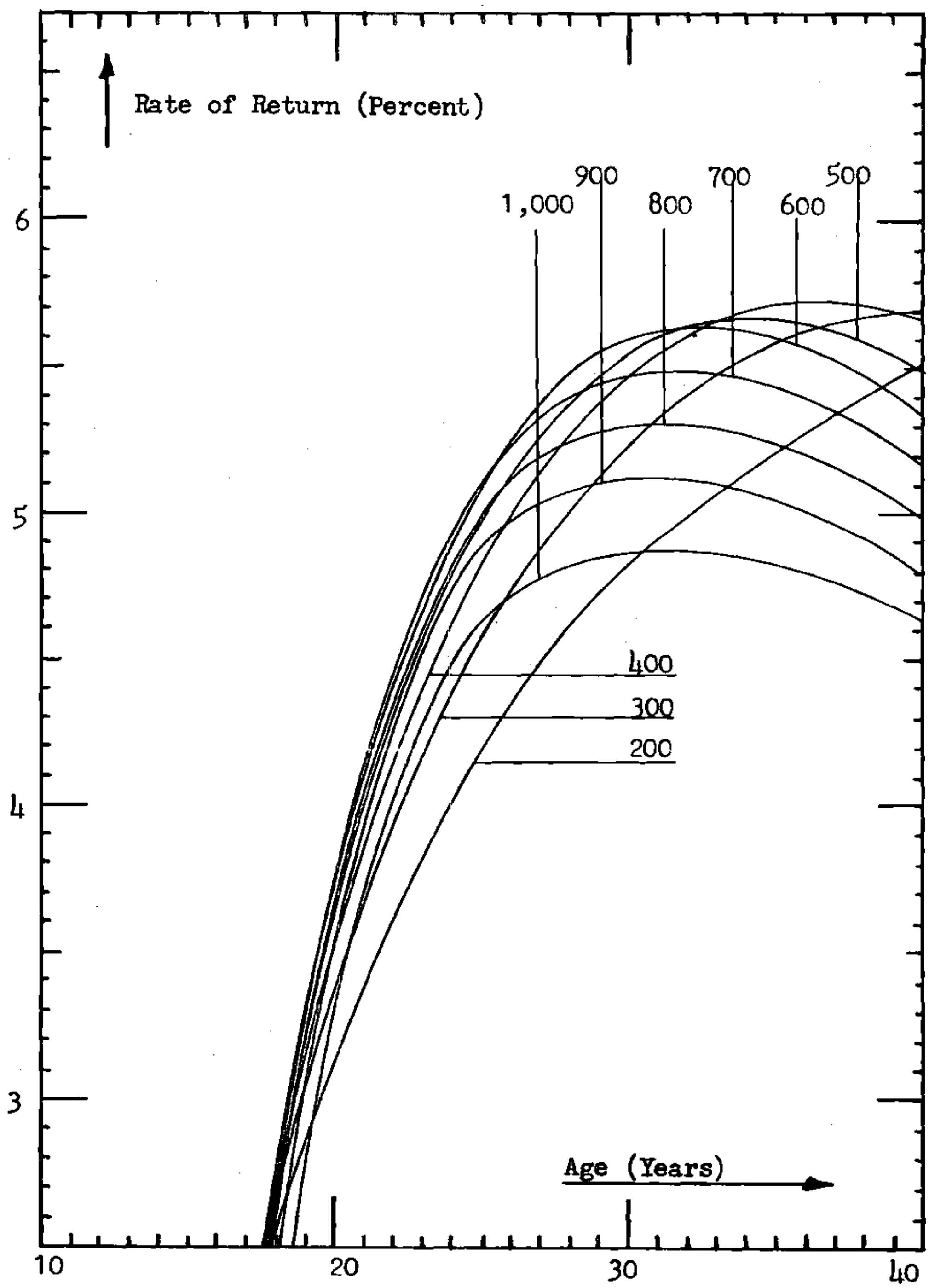

Figure 36. Independent Landowner's Rate of Return on Forest Investment and Growing Cost (Site Clearance Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 50

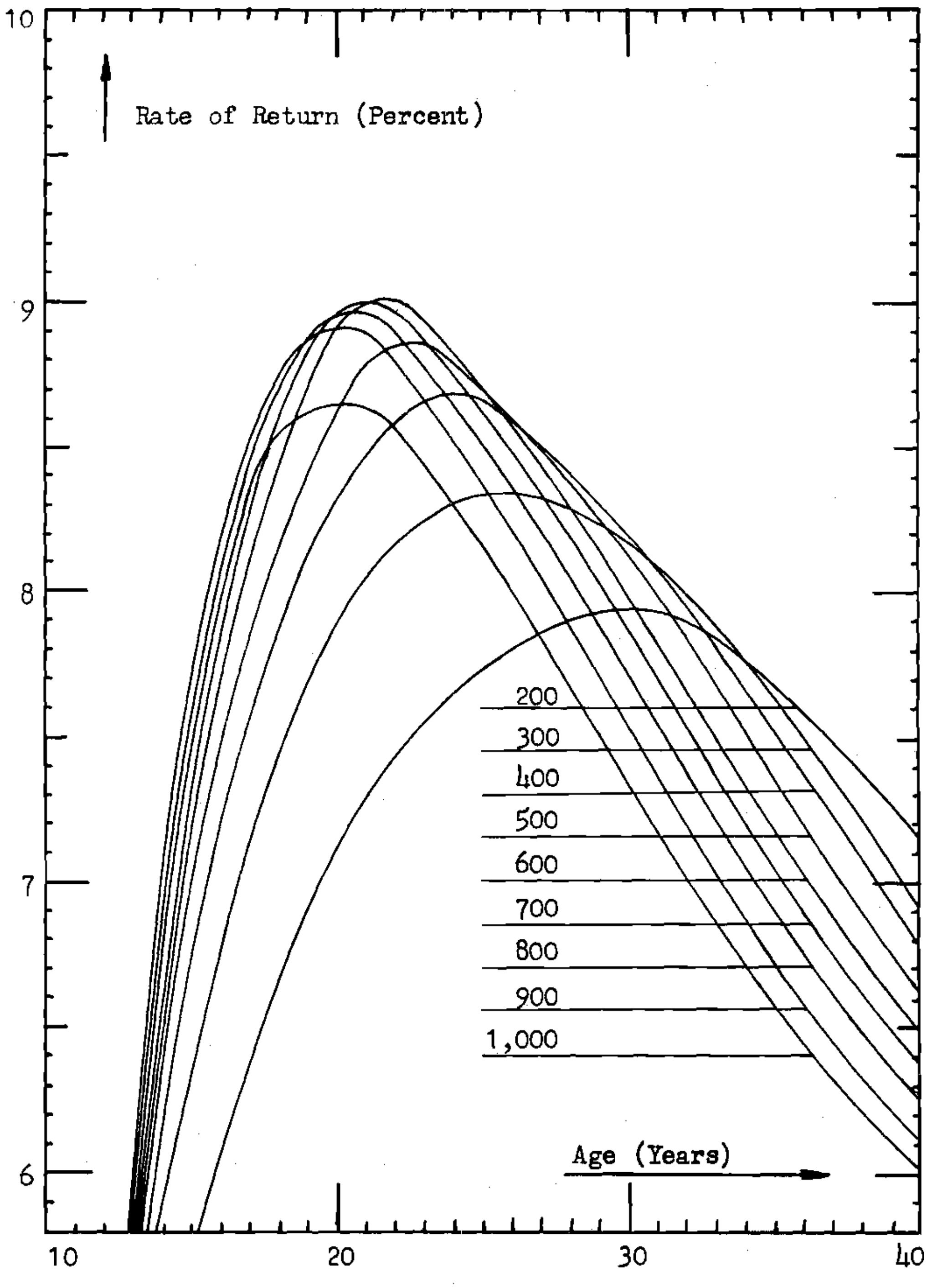

Figure 37. Independent Landowner's Rate of Return on Forest Investment and Growing Cost (Site Clearance Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 70

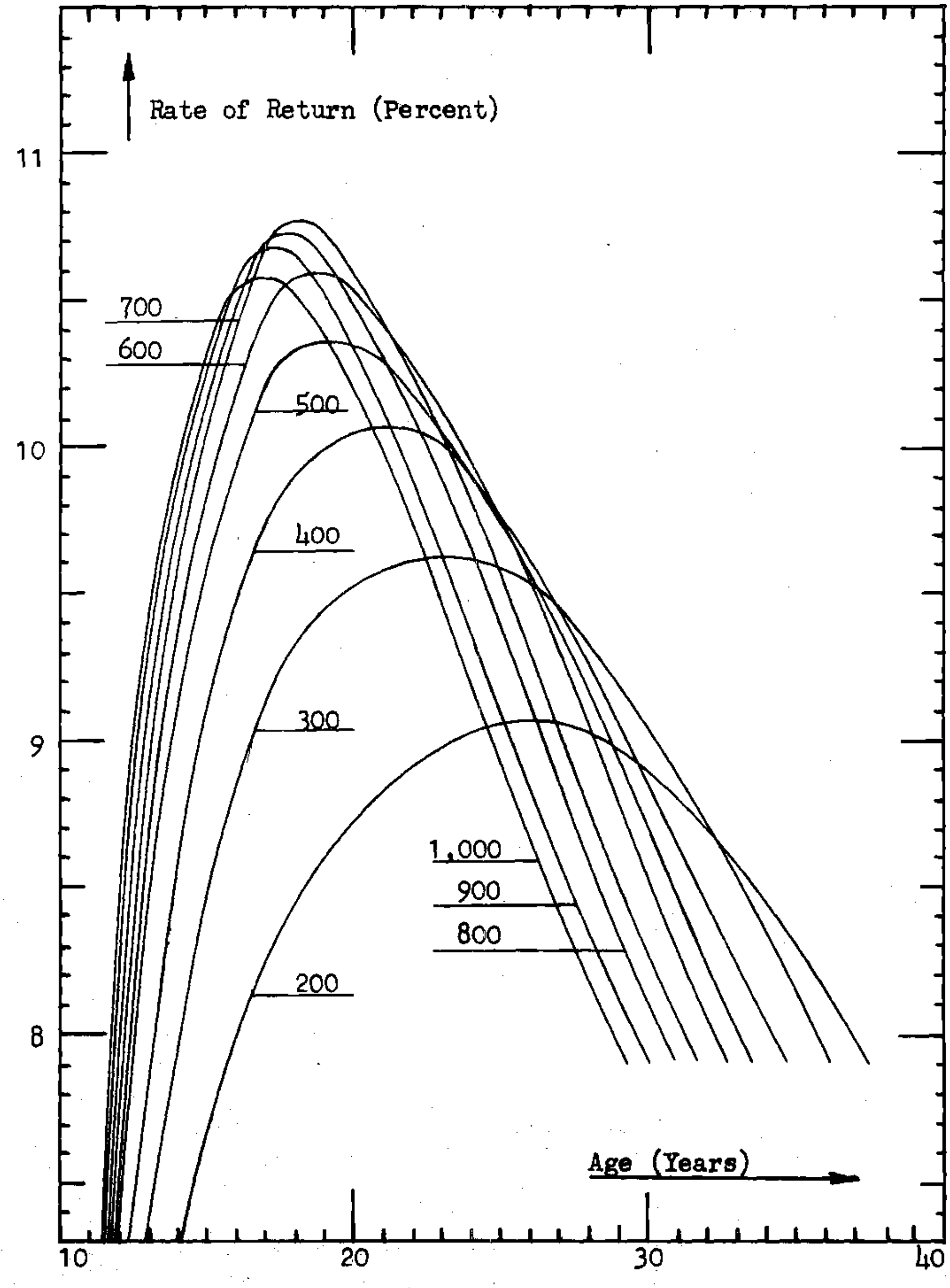

Figure 38. Independent Landowner's Rate of Return on Forest Investment and Growing Cost (Site Clearance Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 80

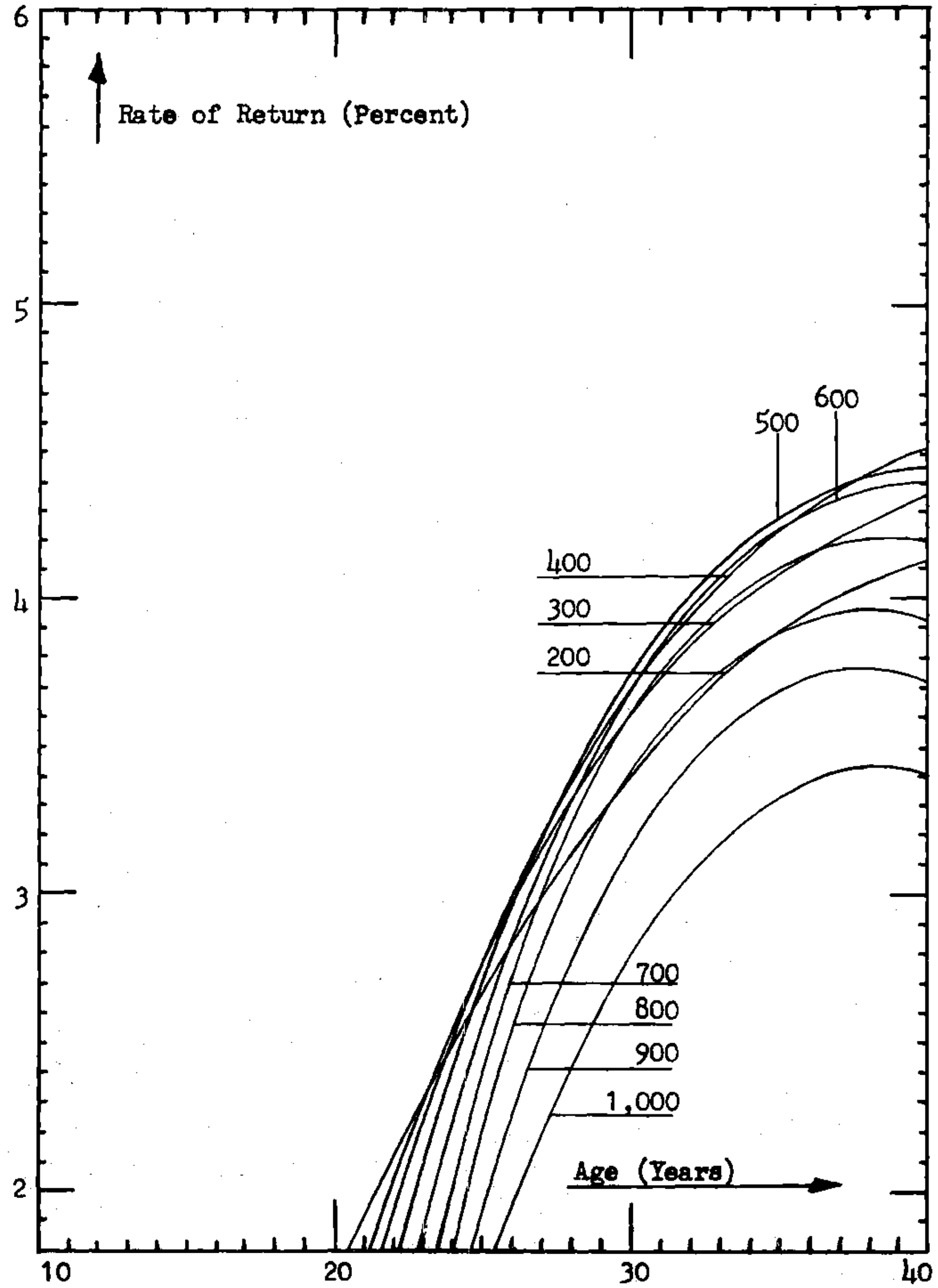

Figure 39. Independent Landowner's Rate of Return on Forest Investment and Growing Cost (Site Clearance Not Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 40

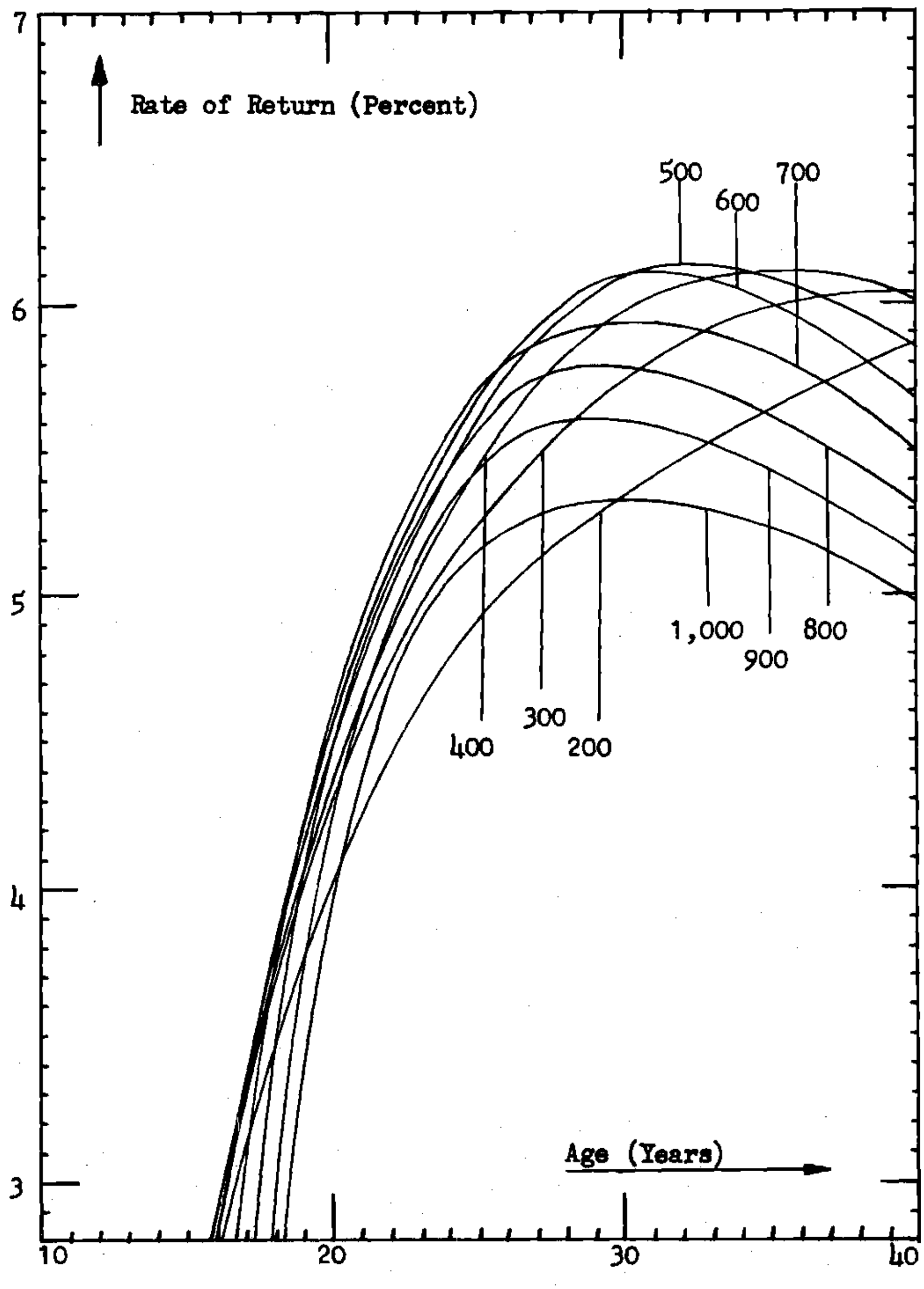

Figure 40. Independent Landowner's Rate of Return on Forest Investment and Growing Cost (Site Clearance Not Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 50

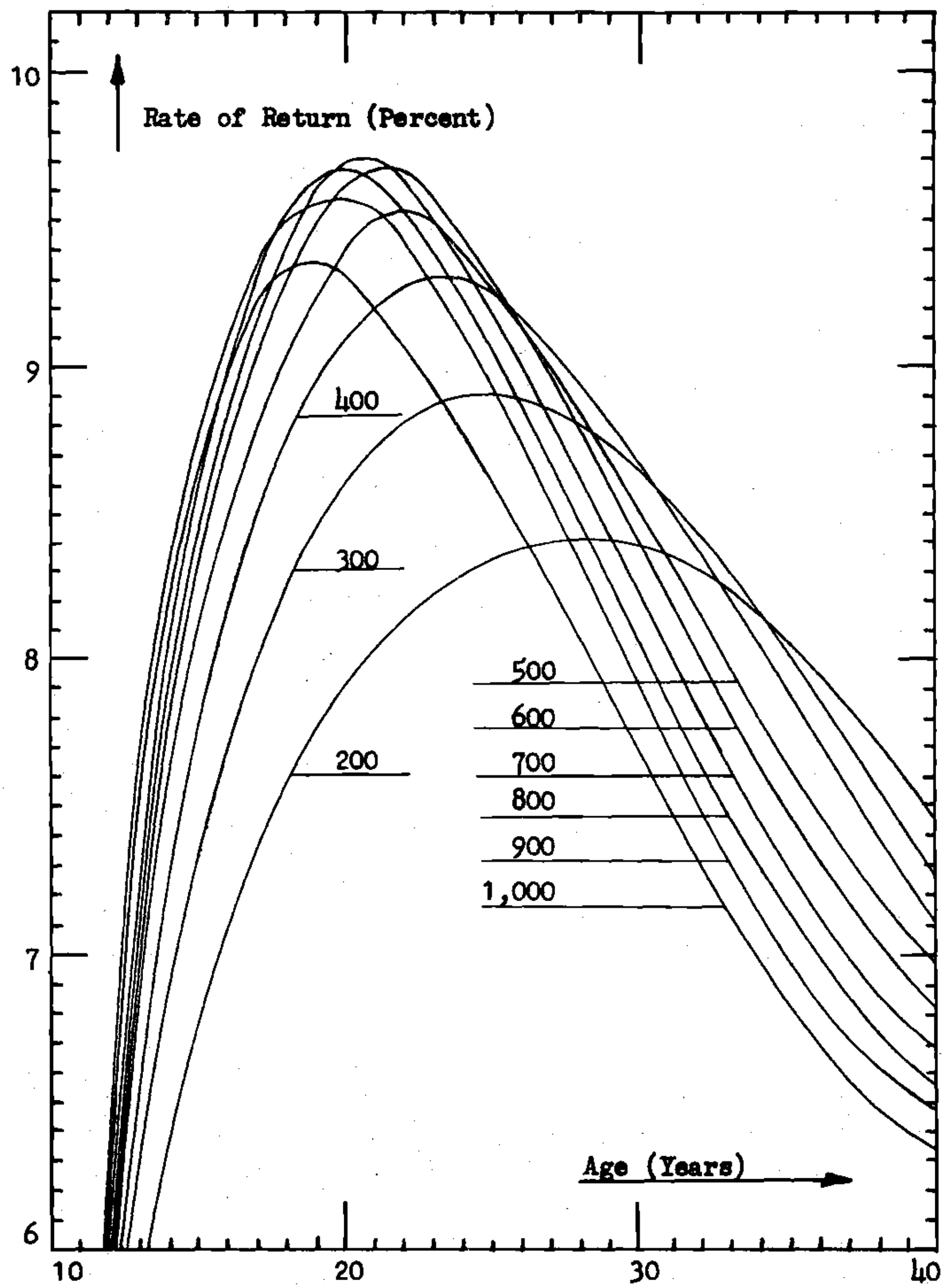

Figure 41. Independent Landowner's Rate of Return on Forest Investment and Growing Cost (Site Clearance Not Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 70

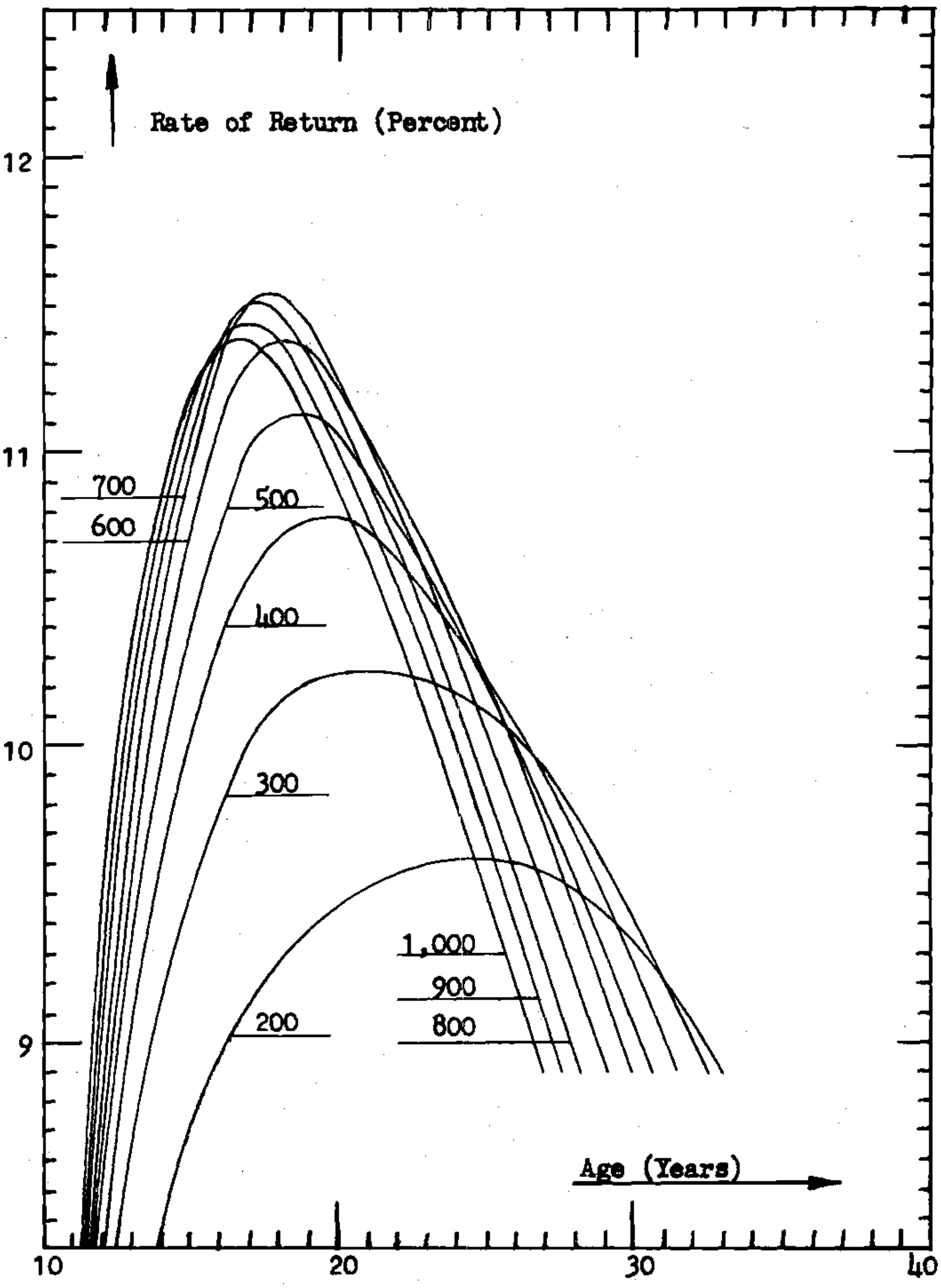

Figure 42. Independent Landowner's Rate of Return on Forest Investment and Growing Cost (Site Clearance Not Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 80

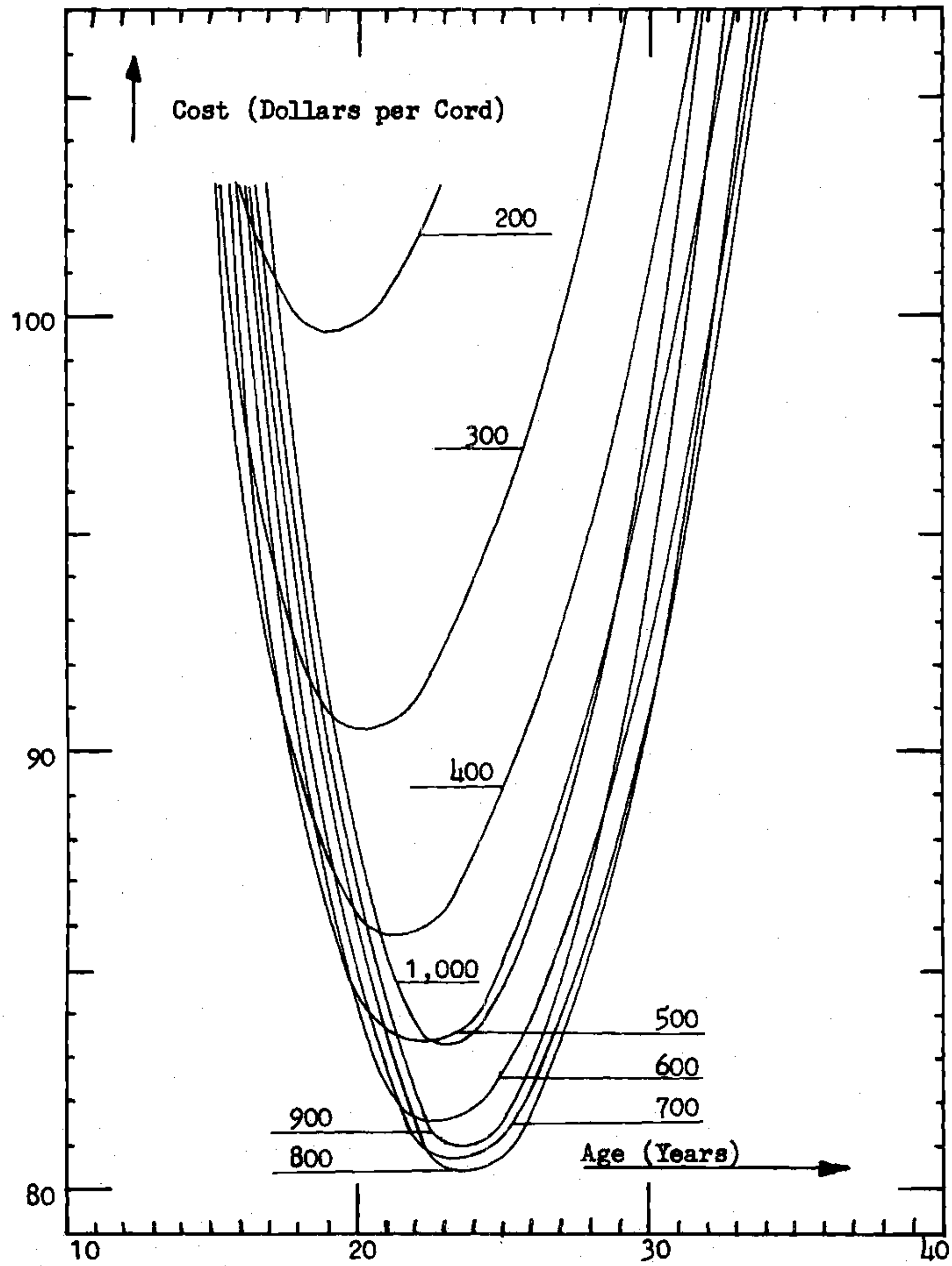

Figure 43. Paper Company's Wood Growing Cost Utilizing Company Industrial Funds (Site Clearance Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 40

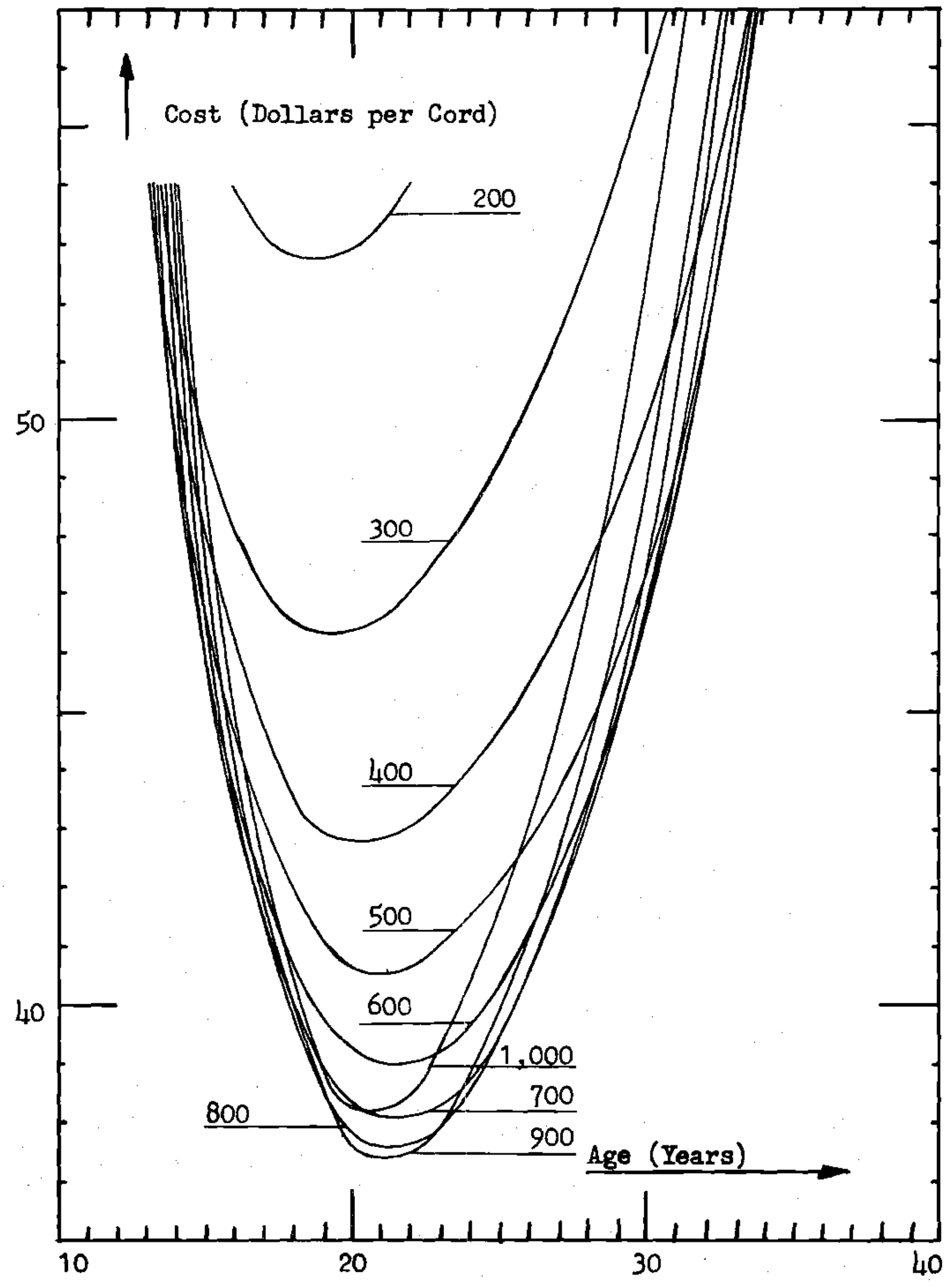

Figure 44. Paper Company's Wood Growing Cost Utilizing Company Industrial Funds (Site Clearance Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 50

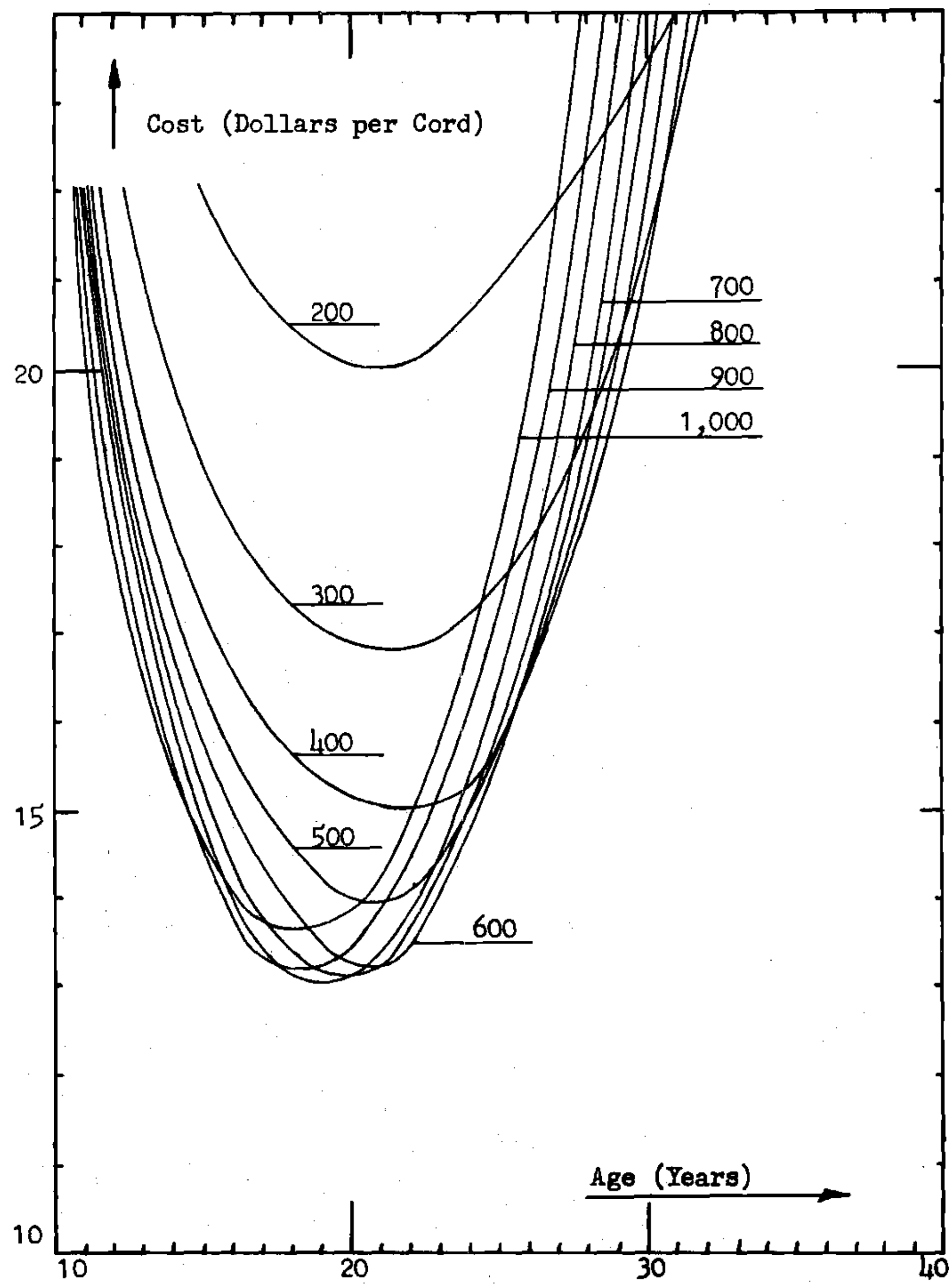

Figure 45. Paper Company's Wood Growing Cost Utilizing Company Industrial Funds (Site Clearance Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 70

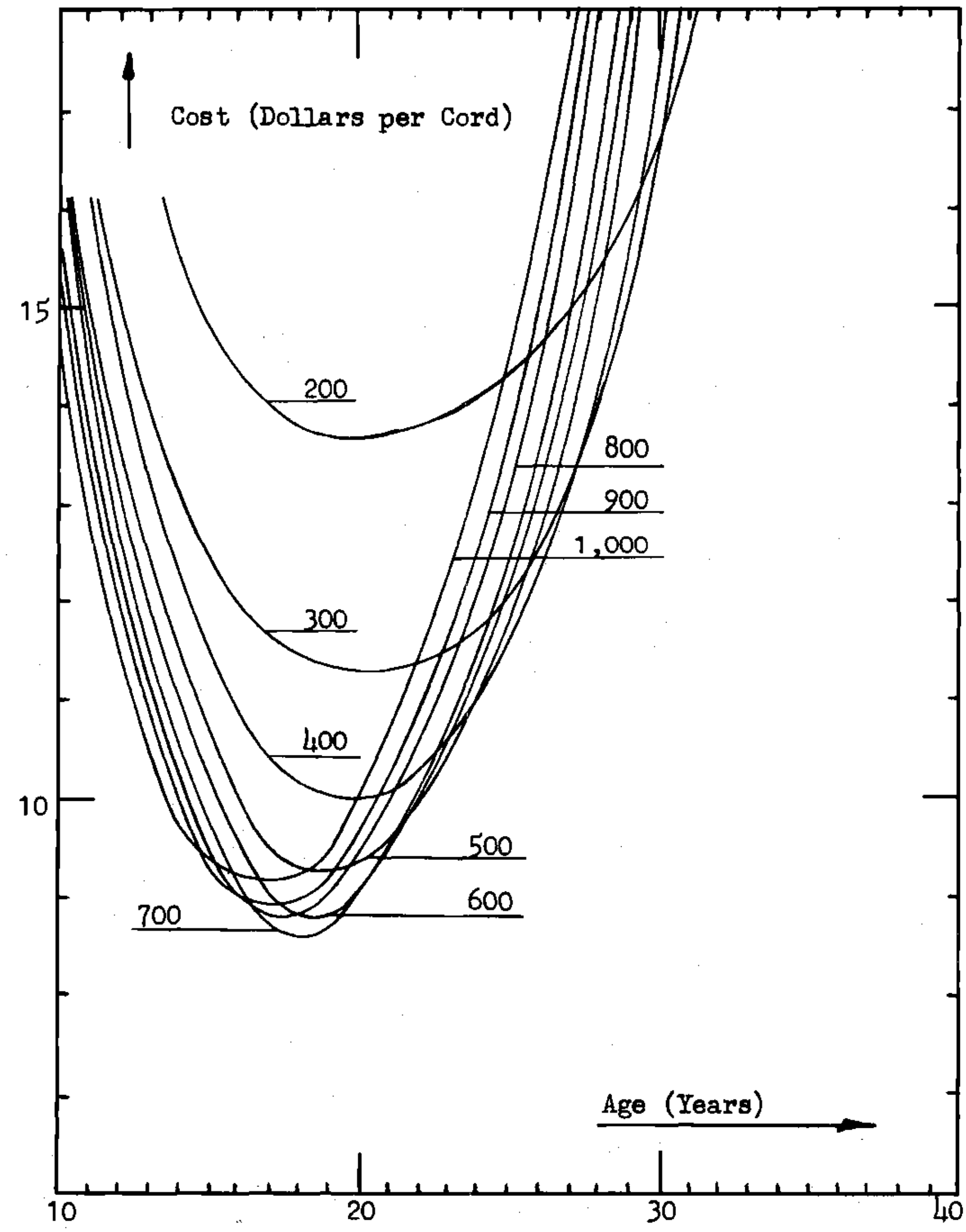

Figure 46. Paper Company's Wood Growing Cost Utilizing Company Industrial Funds (Site Clearance Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 80

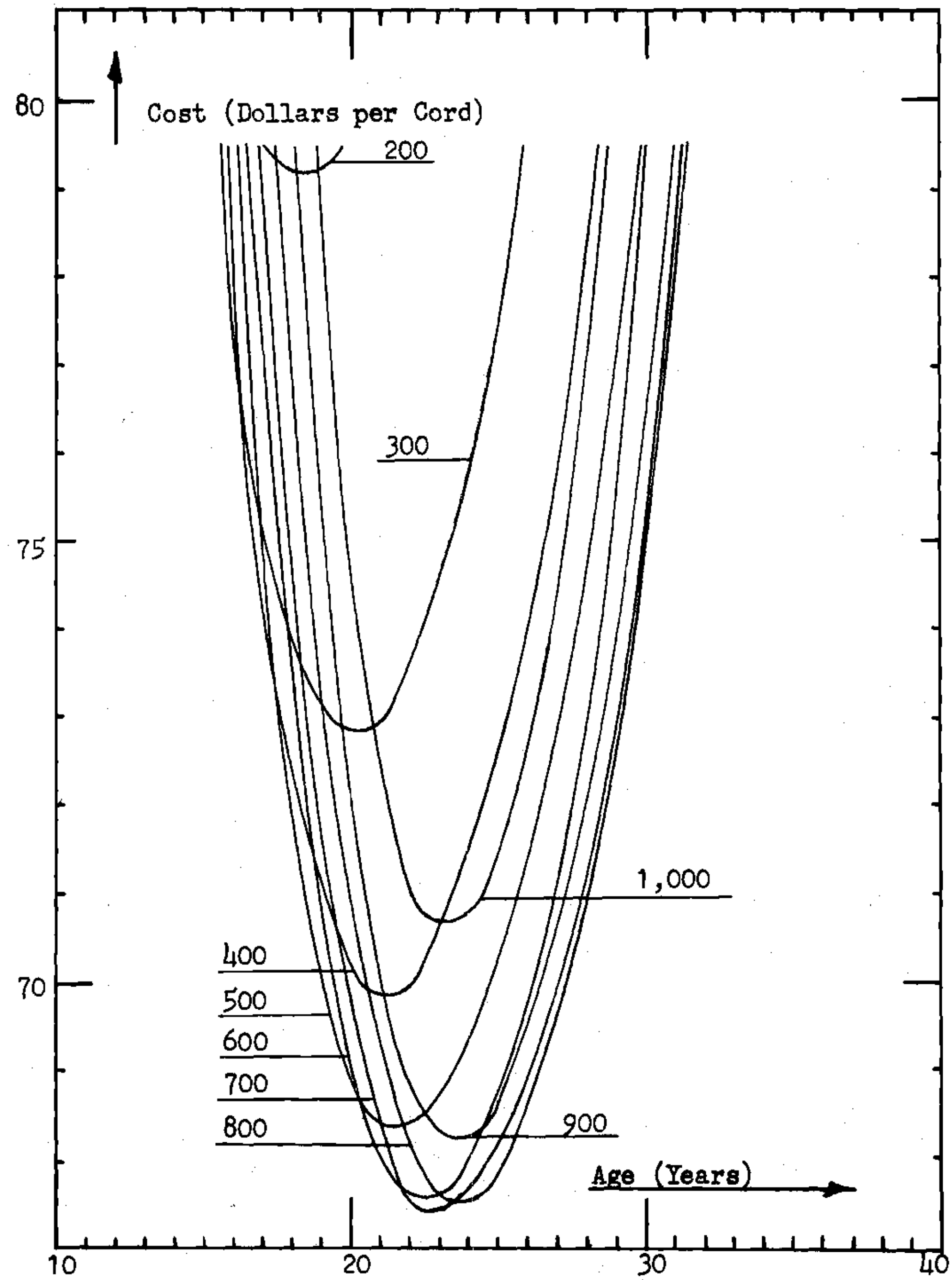

Figure 47. Paper Company's Wood Growing Cost Utilizing Company Industrial Funds (Site Clearance Not Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 40

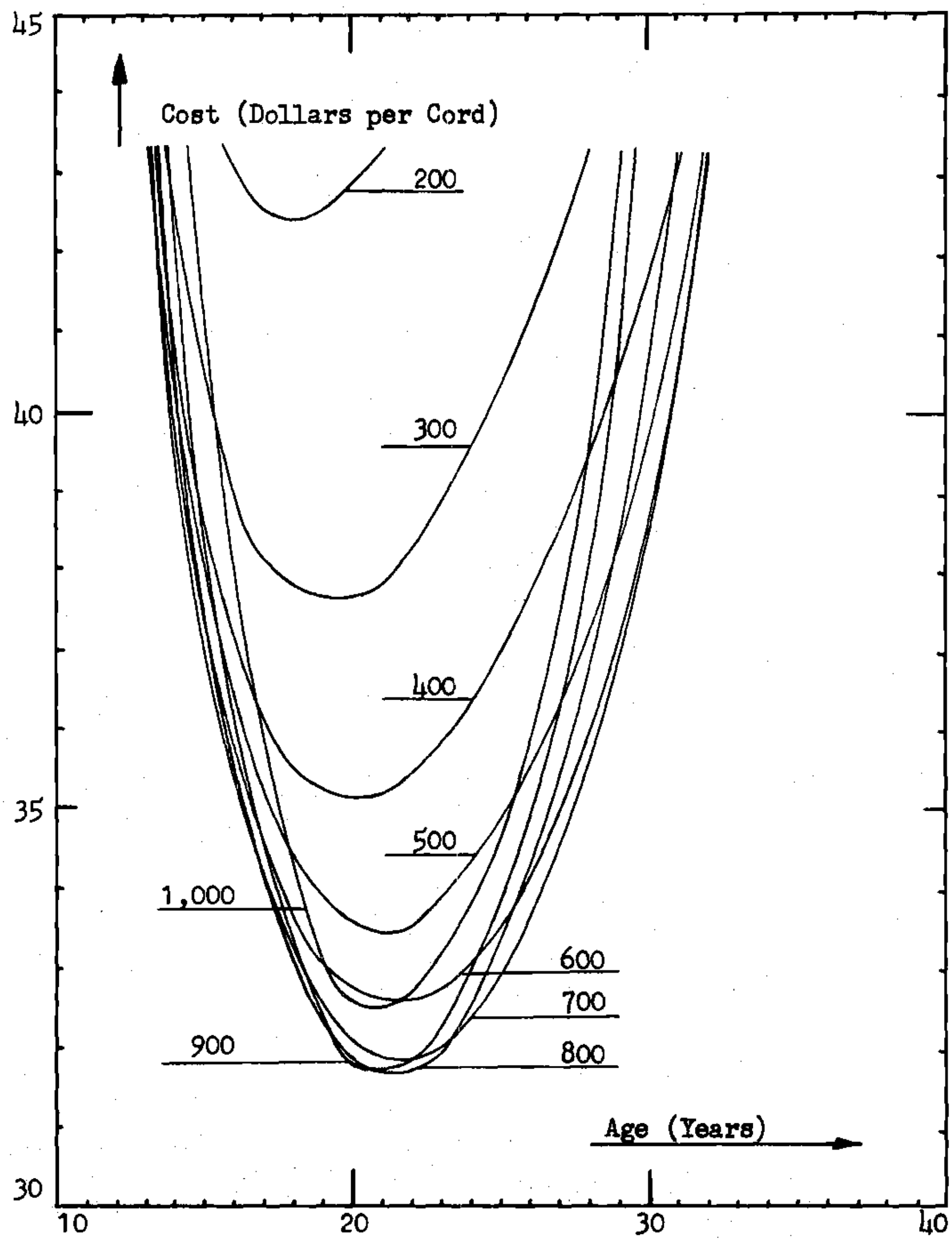

Figure 48. Paper Company's Wood Growing Cost Utilizing Company Industrial Funds (Site Clearance Not Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 50

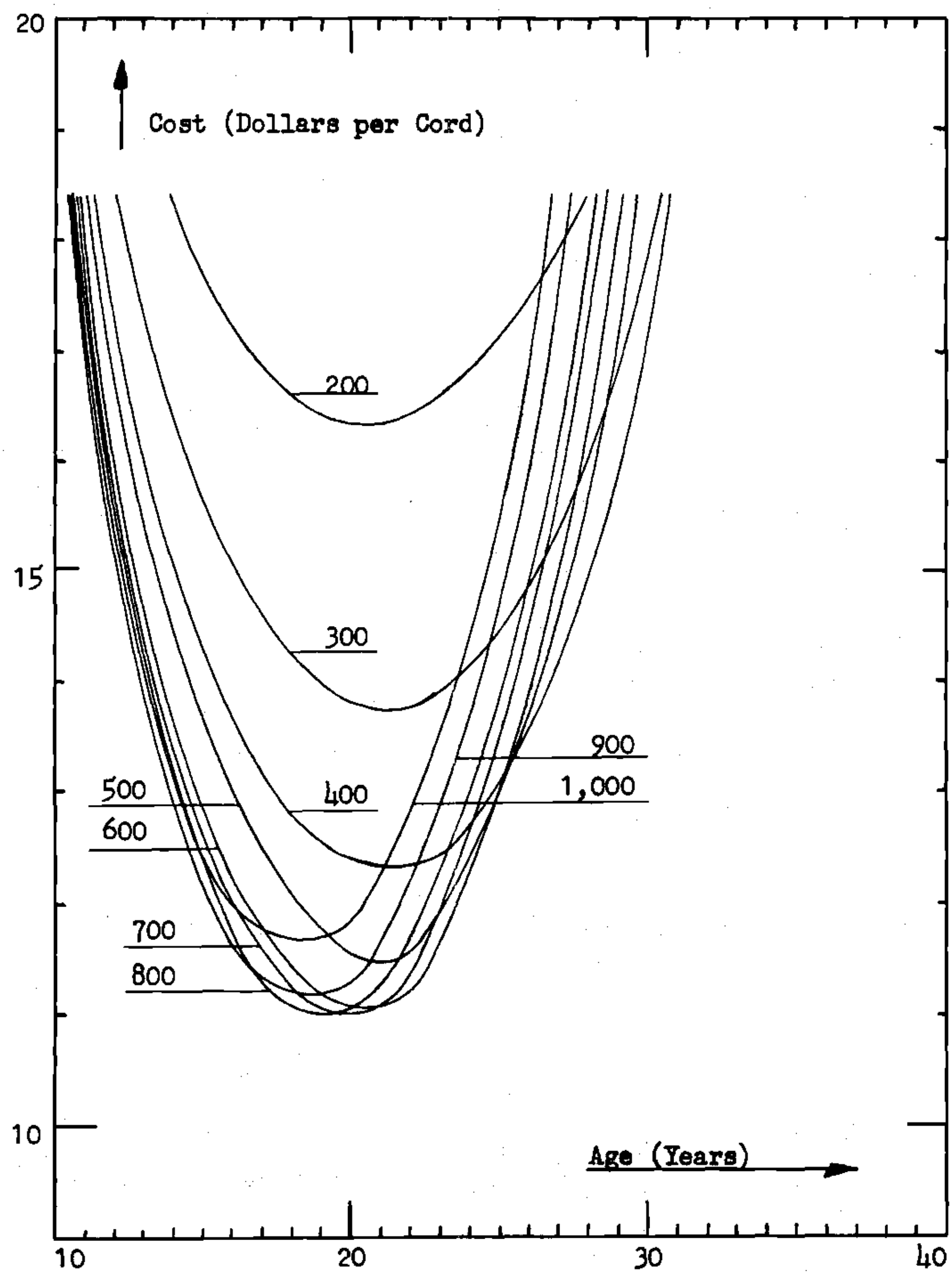

Figure 49. Paper Company's Wood Growing Cost Utilizing Company Industrial Funds (Site Clearance Not Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 70

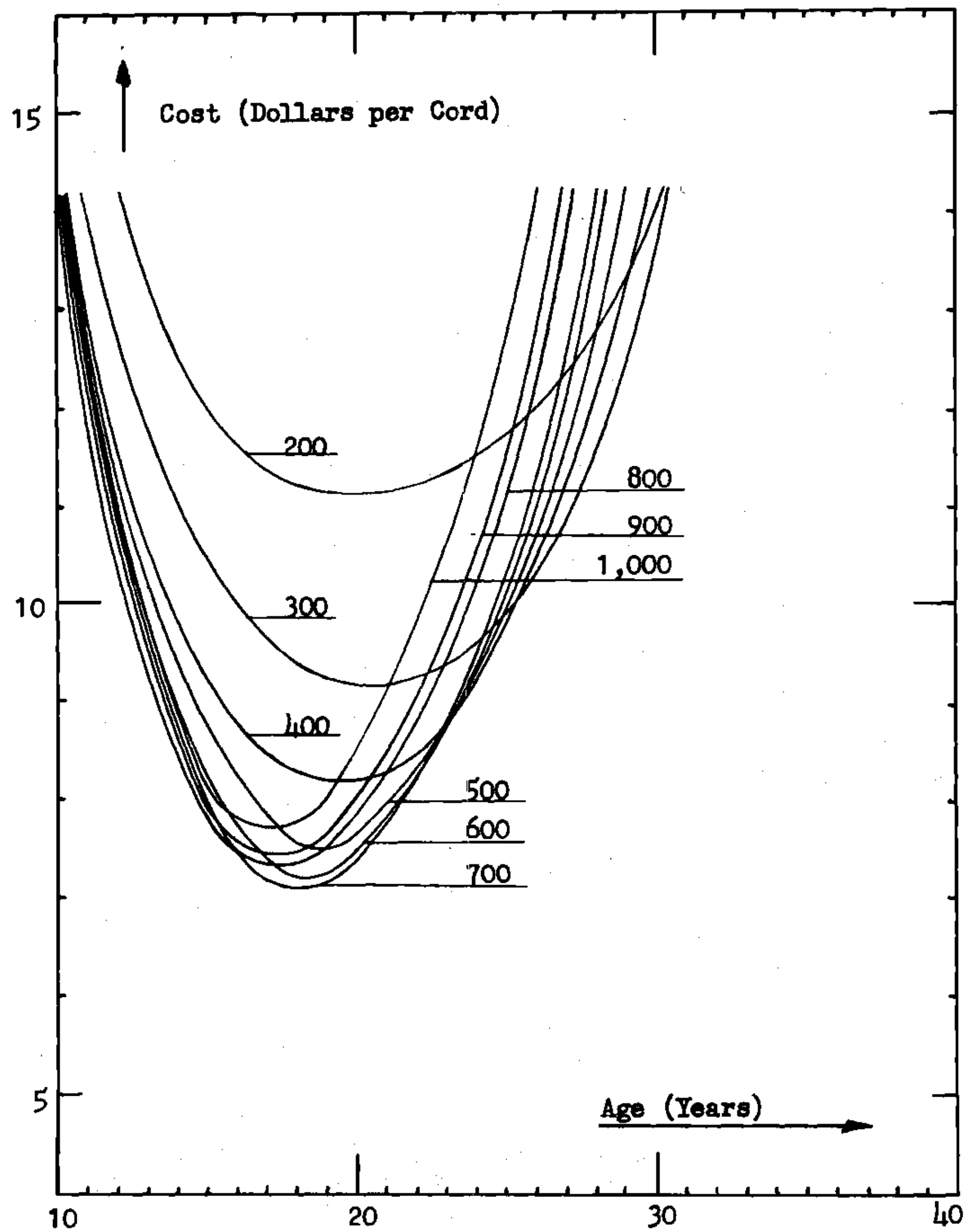

Figure 50. Paper Company's Wood Growing Cost Utilizing Company Industrial Funds (Site Clearance Not Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 80

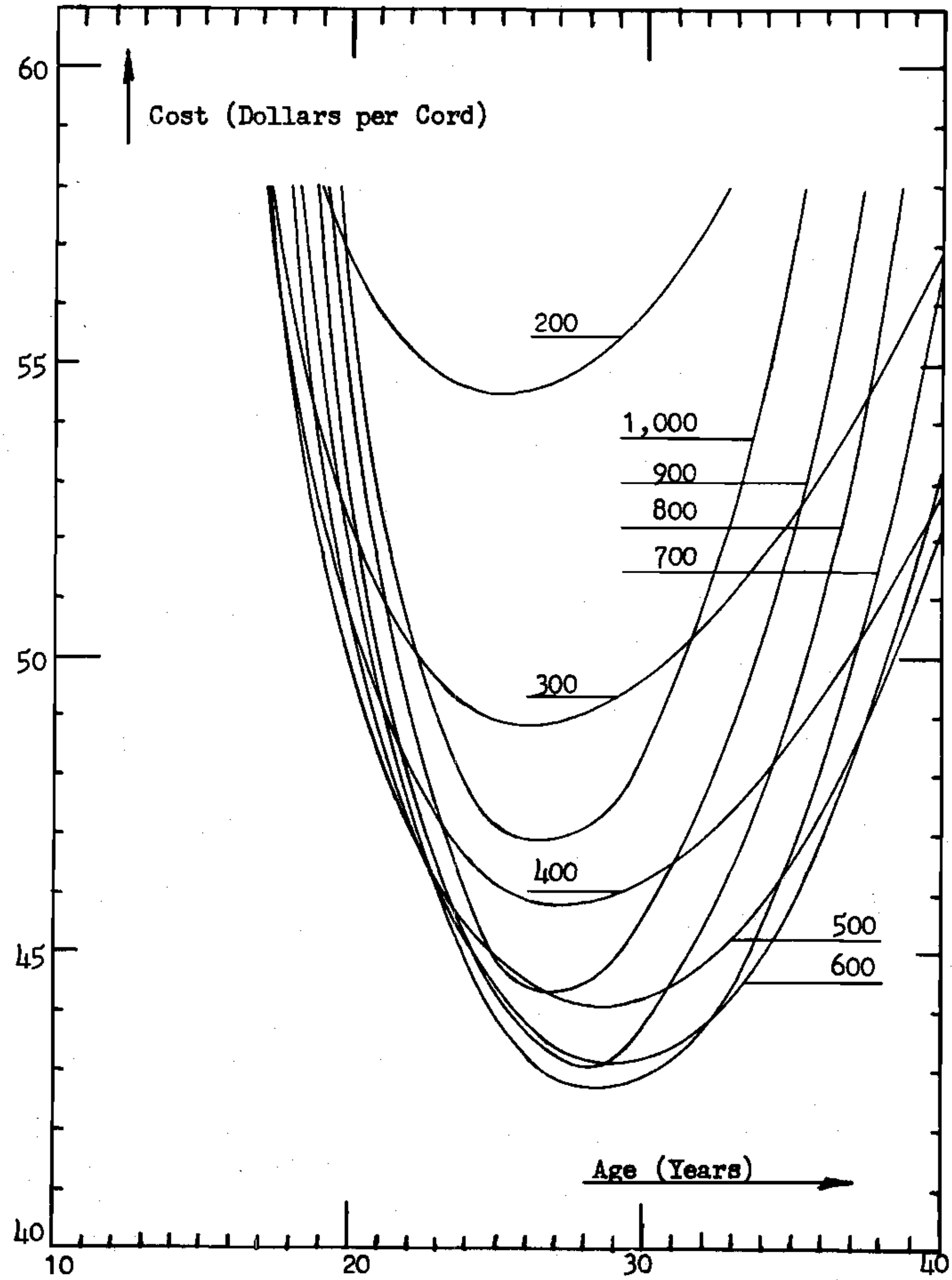

Figure 51. Paper Company's Wood Growing Cost at 6 Percent Interest on Forest Investment and Growing Cost (Site Clearance Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 40

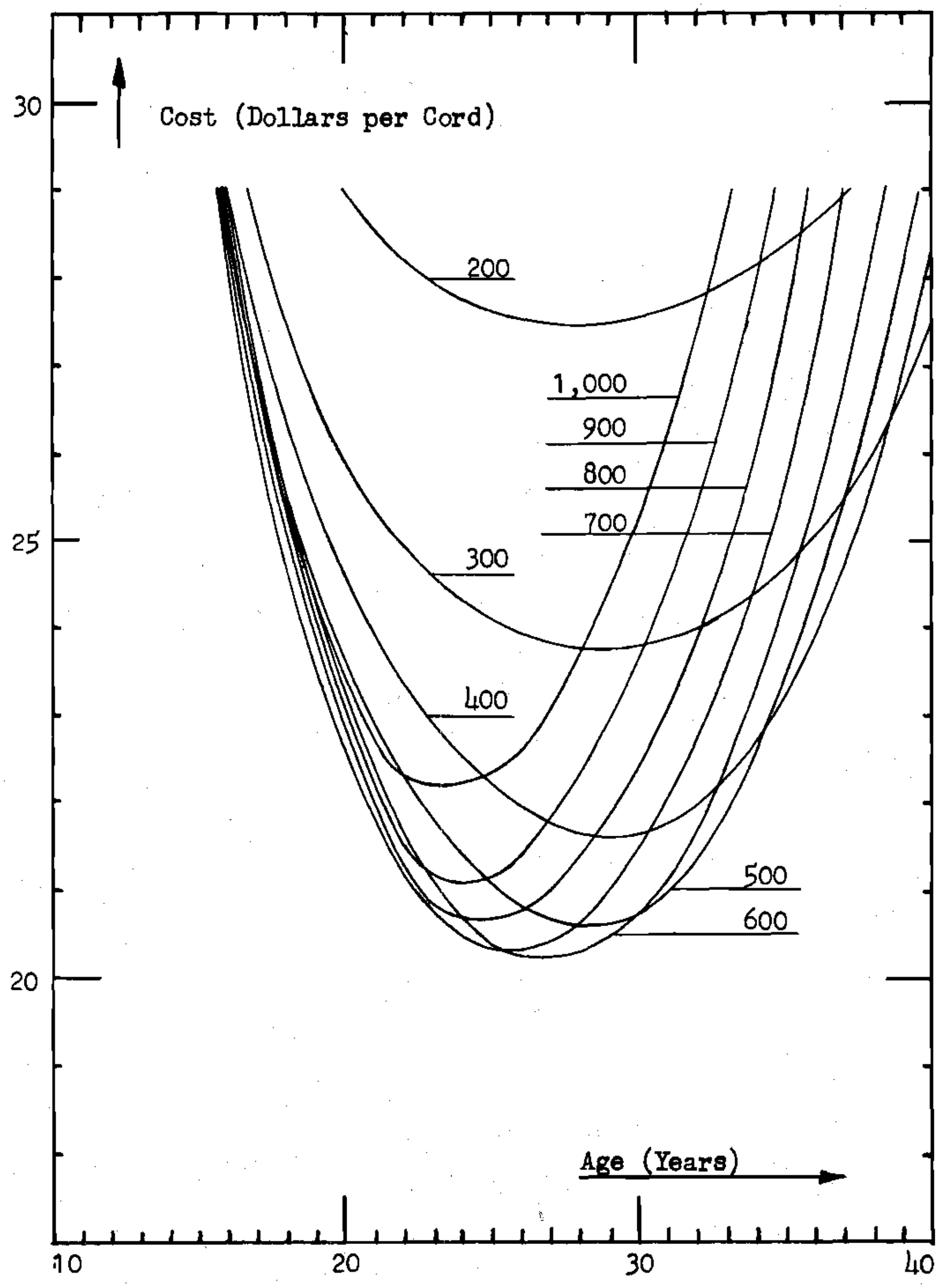

Figure 52. Paper Company's Wood Growing Cost at 6 Percent Interest on Forest Investment and Growing Cost (Site Clearance Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 50

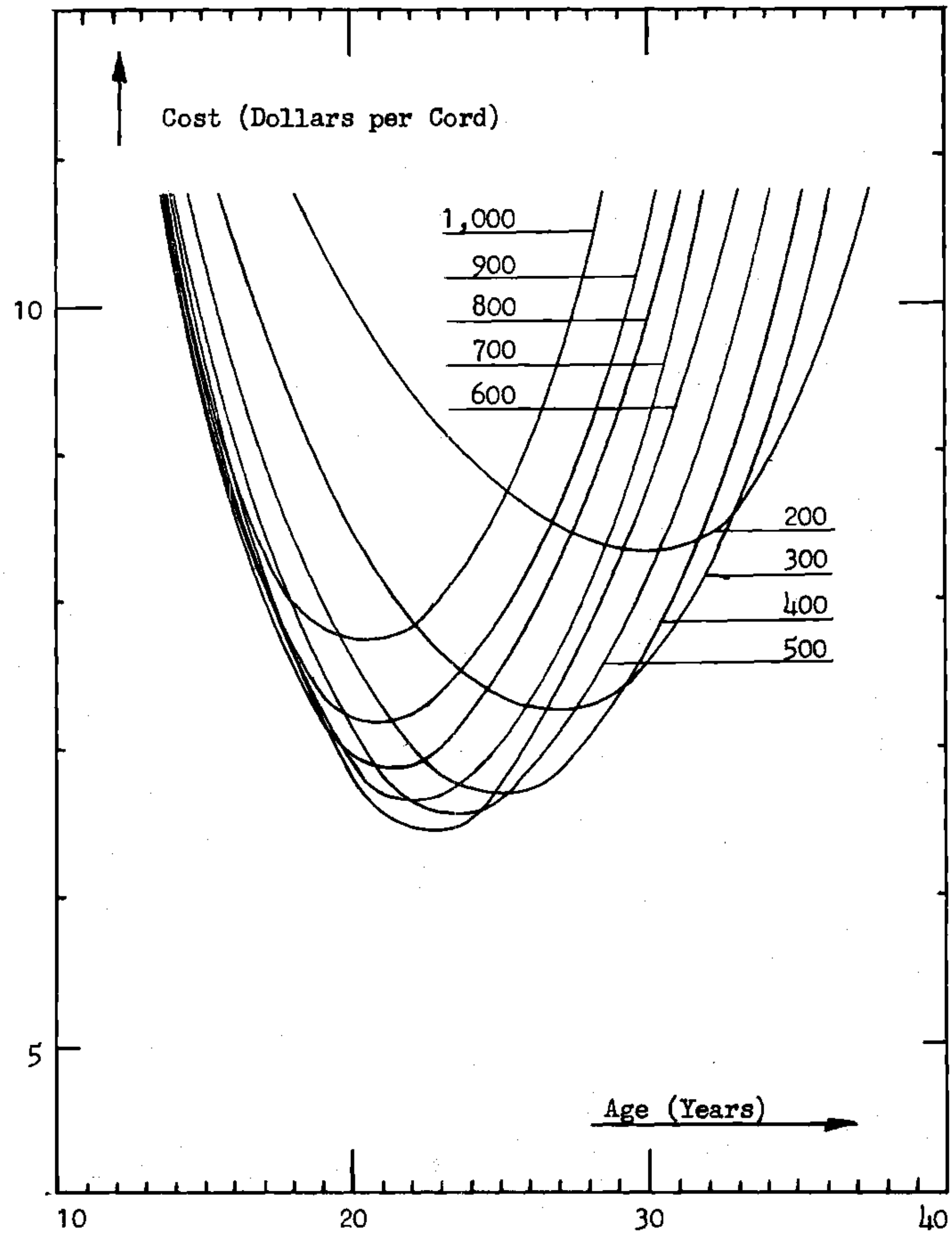

Figure 53. Paper Company's Wood Growing Cost at 6 Percent Interest on Forest Investment and Growing Cost (Site Clearance Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 70

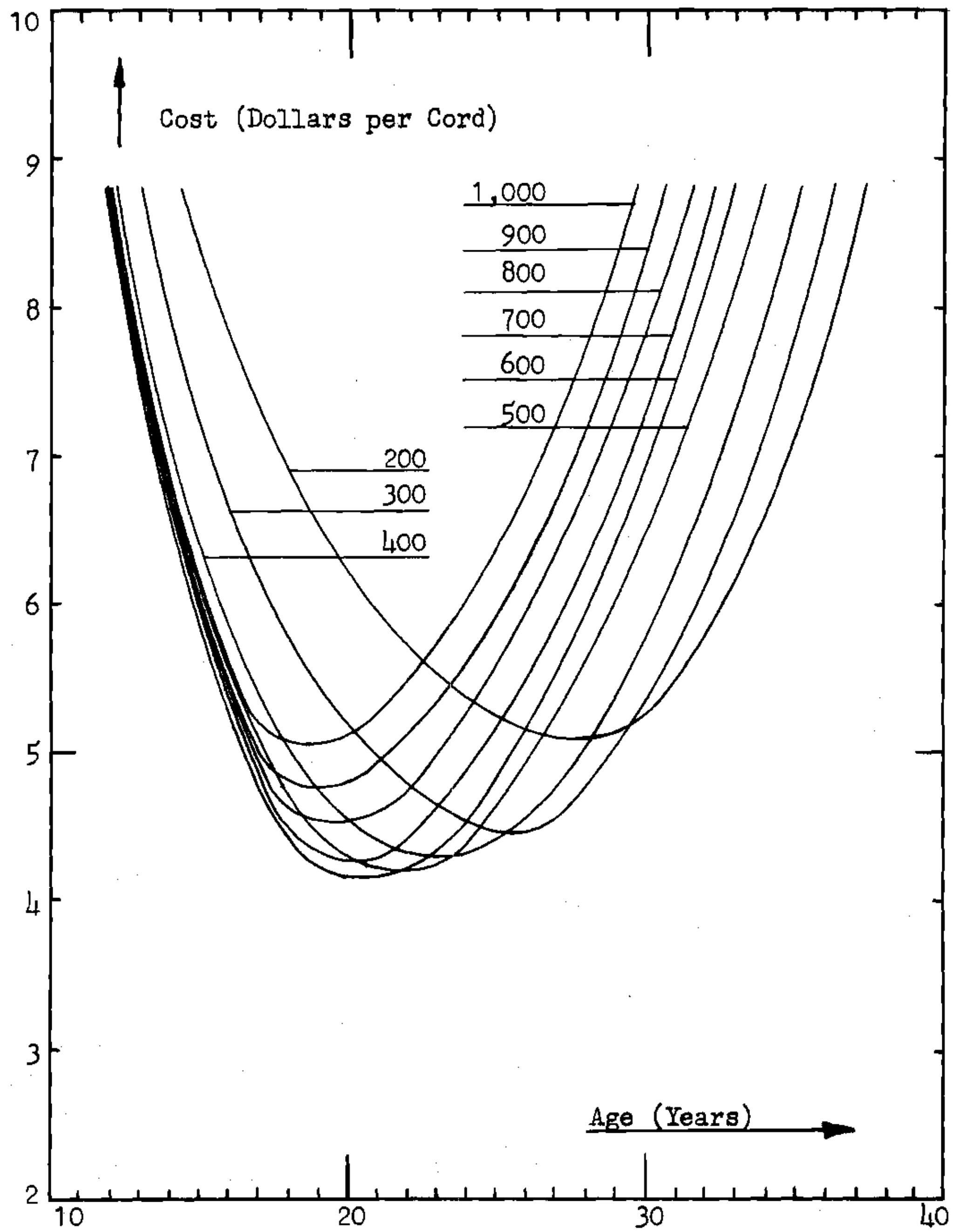

Figure 54. Paper Company's Wood Growing Cost at 6 Percent Interest on Forest Investment and Growing Cost (Site Clearance Required) versus Age for Initial Planting Densities of 200 to 1,000 Trees per Acre on Land with Site Index 80

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